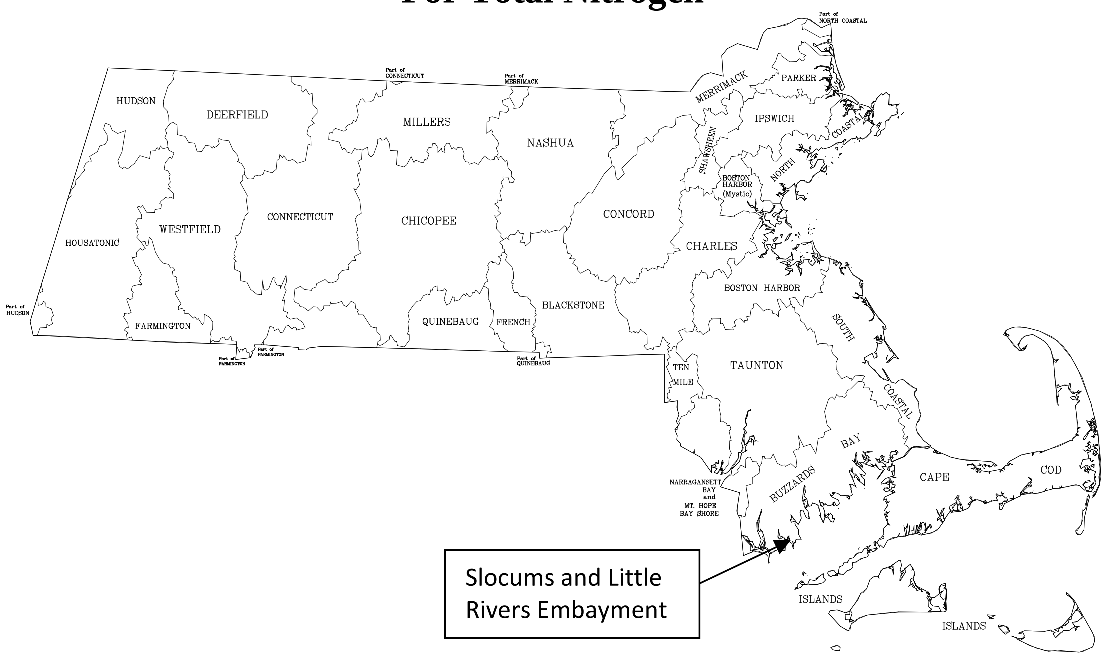
DRAFT
Slocums and Little Rivers Embayment System Total Maximum Daily Loads For Total Nitrogen (CN 315.0)

COMMONWEALTH OF MASSACHUSETTS
EXECUTIVE OFFICE OF ENERGY AND ENVIRONMENTAL AFFAIRS
MATTHEW A. BEATON, SECRETARY
MASSACHUSETTS DEPARTMENT OF ENVIRONMENTAL PROTECTION
MARTIN SUUBERG, COMMISSIONER
BUREAU OF WATER RESOURCES
DOUGLAS FINE, ASSISTANT COMMISSIONER
August 2018

Draft
Slocums and Little Rivers Embayment System
Total Maximum Daily Loads
For Total Nitrogen



Key Feature: Total Nitrogen TMDL for Slocums and Little Rivers

Location: EPA Region 1

Land Type: New England Coastal

303d Listing: Slocums River (MA95-34) is impaired and in Category 5 of the 2014 Integrated Report for Total Nitrogen, Bioestuarine Assessments and Pathogens. Little River (MA95-66) is in Category 5 for Total Nitrogen but was not found to be impaired for nutrients during the course of the MEP study. Paskamansett River (MA95-11) is in Category 3, "No Uses Assessed." Destruction Brook was found to be impaired for nutrients during the MEP study and will be listed in a future List of Water as impaired.

Data Sources: University of Massachusetts – Dartmouth/School for Marine Science and Technology; US Geological Survey; Applied Coastal Research and Engineering, Inc.; Southeast Regional Planning & Economic Development District, Town of Dartmouth

Data Mechanism: Massachusetts Surface Water Quality Standards, Ambient Data, and Linked Watershed Model

Monitoring Plan: Buzzards Bay Coalition's Baywatcher Monitoring Program**,** Town of Dartmouth monitoring program with technical assistance from SMAST

Control Measures: Sewering, Storm Water Management, Attenuation by Impoundments and Wetlands, Fertilizer Use By-laws, Agricultural BMPs

Executive Summary

Problem Statement

Excessive nitrogen (N) originating from a range of sources has added to the impairment of the environmental quality of the Slocums and Little Rivers Embayment System. In general, excessive N in these waters is indicated by:

- Loss of eelgrass beds, which are critical habitats for macroinvertebrates and fish
- Undesirable increases in macro algae, which are much less beneficial than eelgrass
- Periodic extreme decreases in dissolved oxygen concentrations that threaten aquatic life
- Reductions in the diversity of benthic animal populations
- Periodic algae blooms

With proper management of N inputs these trends can be reversed. Without proper management more severe problems might develop, including:

- Periodic fish kills
- Unpleasant odors and scum
- Benthic communities reduced to the most stress-tolerant species, or in the worst cases, near loss of the benthic animal communities

The water and habitat quality of the Little and Barney's Joy Rivers are presently considered to be "healthy", and no reductions of N loading are called for. However, this document serves to notify the Town of Dartmouth that the target N loading rates to these two systems are protective and should be maintained as closely as possible in order to prevent future impairments.

Coastal communities rely on clean, productive, and aesthetically pleasing marine and estuarine waters for tourism, recreational swimming, fishing, and boating, as well as for commercial fin fishing and shellfishing. Failure to reduce and control N loadings could result in complete replacement of eelgrass by macro-algae, a higher frequency of extreme decreases in dissolved oxygen concentrations and fish kills, widespread occurrence of unpleasant odors and visible scum, and a complete loss of benthic macroinvertebrates throughout most of the embayment. As a result of these environmental impacts, commercial and recreational uses of Slocums and Little Rivers Embayment System coastal waters will be greatly reduced.

Sources of Nitrogen

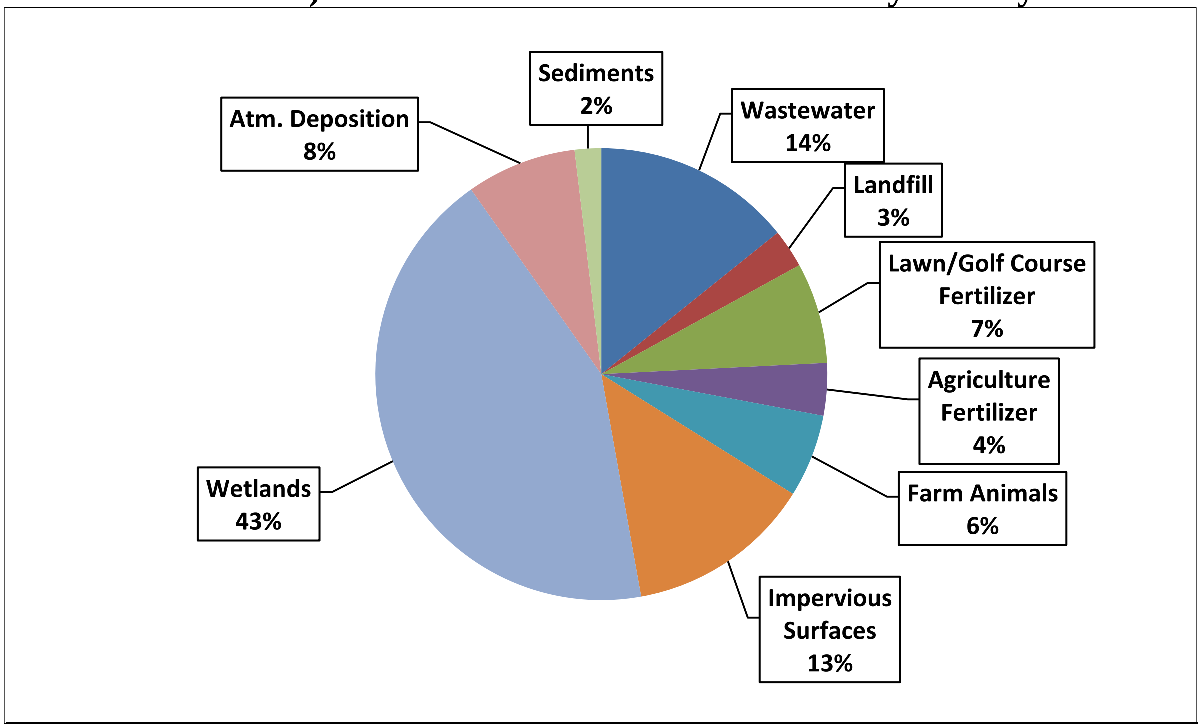
Nitrogen enters the waters of coastal embayments from the following sources:

- The watershed
  - Natural background
  - Septic Systems
  - Runoff
  - Fertilizers
  - Wastewater treatment facilities
  - Landfills

    - Agricultural activities
- Atmospheric deposition
- Nutrient-rich bottom sediments in the embayments

Figure ES-A below illustrates the percent contributions of all of the sources of N into the Slocums and Little Rivers Embayment System. Values are based on unattentuated loads from Table IV-6 from the Massachusetts Estuaries Project (MEP) Technical Report. As evident, the uncontrollable loads from atmospheric deposition, sediments and wetlands account for over half of the total load to this system. Most of the present *controllable* load is divided approximately equally between septic systems and runoff. Fertilizer sources (agriculture, lawn and golf courses combined) are a close second.

Figure ES-A: Percent Contributions of All Nitrogen Sources (Controllable and Uncontrollable) to Slocums and Little Rivers Embayment System



Target Threshold N Concentrations and Loadings

The N loadings (the quantity of N) to this embayment system ranged from 7.54 kg/day in Barneys Joy River (North and South) to 120 kg/day in Paskamansett River and Destruction Brook, with a total present load for the entire system of 154.78 kg/day. (These loadings are taken from Table ES-1 of the MEP Technical Report.) The resultant concentrations of N in this embayment ranged from 1.52 mg/L to 0.26 mg/L (range of average yearly means collected from 12 stations during 2000-2006 as reported in Table VI-1 of the MEP Technical Report).

In order to restore and protect this embayment system, N loadings, and subsequently the concentrations of N in the water, must be reduced to levels below those that cause the observed environmental impacts. This N concentration will be referred to as the *target threshold N concentration*. It is the goal of the TMDL to reach this target threshold N concentration, as it has been determined for each impaired waterbody segment. The Massachusetts Estuaries Project (MEP) has determined that by achieving N concentrations of 0.36 mg/L near sentinel station SRT-12 in the Slocums River and staying below a N concentration of 0.50 mg/L near sentinel station SRT-15 in the Little River (see Figure 5), eelgrass and benthic macroinvertebrate habitat quality will be restored in the Slocums River system and water and benthic habitat quality will be protected in the Little River system.

The mechanism for achieving the target threshold N concentrations is to reduce the N loadings to various portions of the Slocums River embayment system and maintain N loadings to the Little River. Based on the MEP sampling and modeling analyses and their Technical Report, the MassDEP has determined that in order to meet the target threshold N concentration a Total Maximum Daily Load (TMDL) of 144.35 kg total N/day will be needed for all water bodies in the Slocums and Little Rivers embayment system. Specifically, this calls for a reduction of 23.8% of the watershed N load within the Slocums River watershed and an 11.3% reduction of the watershed N load within the Paskamansett River and Destruction Brook watersheds. The water and habitat quality of the Little and Barney's Joy Rivers are presently considered to be "healthy" and no reductions of N loading are called for within their watersheds.

This document presents the TMDLs for this water body system and provides guidance to the watershed communities of Dartmouth and New Bedford on possible ways to reduce the N loadings to within the recommended TMDL and protect the waters for this embayment system.

Implementation

The primary goal of TMDL implementation will be lowering the concentrations of N. This can be achieved by reducing septic system loadings in the Slocums River by 76% and in the Paskamansket River/Destruction Brook subwatersheds by 80%, however, there are a variety of loading reduction scenarios that could achieve the target threshold N concentration. Local officials can explore other loading reduction scenarios through additional modeling as part of their Comprehensive Wastewater Management Plan (CWMP). Implementing best management practices (BMPs) to reduce N loadings from fertilizers, agriculture and runoff from impervious cover where possible will also help to lower the total N load to these systems. The recommended method of TMDL implementation will likely be a combination of reducing the loadings from any and all sources of N in the watershed. The appropriateness of any of the alternatives will depend on local conditions and will have to be determined on a case-by-case basis using an adaptive management approach. Methodologies for reducing N loading from septic systems, stormwater runoff and fertilizers are provided in detail in the "MEP Embayment Restoration and Guidance for Implementation Strategies", available on the MassDEP website: (http://www.mass.gov/dep/water/resources/coastalr.htm#guidance).

Since approximately 25% of the upper watershed of the Slocums River embayment is located in New Bedford (http://www.epa.gov/region1/npdes/stormwater/ma.html) the development of any implementation plan should keep in mind that Dartmouth and New Bedford should coordinate efforts to maximize the reduction in N loading. MassDEP recognizes that the Dartmouth has taken numerous steps to reduce nitrogen loads to the watershed since the start of the data collection period (2000-2006). Some of the Town's actions are provided in the Implementation section of the TMDL report. Growth within the communities of Dartmouth and New Bedford that would exacerbate the problems associated with N loadings, should be guided by considerations of water quality-associated impacts.

Table of Contents

List of Figures

List of Tables

Introduction

Section 303(d) of the Federal Clean Water Act requires each state (1) to identify waters that are not meeting water quality standards and (2) to establish Total Maximum Daily Loads (TMDLs) for such waters for the pollutants of concern. The TMDL allocation establishes the maximum loadings (of pollutants of concern) from all contributing sources that a water body may receive and still meet and maintain its water quality standards and designated uses, including compliance with numeric and narrative standards. The TMDL development process may be described in four steps, as follows:

1. Determination and documentation of whether or not a water body is presently meeting its water quality standards and designated uses.

2. Assessment of present water quality conditions in the water body, including estimation of present loadings of pollutants of concern from both point sources (discernible, confined, and concrete sources such as pipes) and non-point sources (diffuse sources that carry pollutants to surface waters through runoff or groundwater).

3. Determination of the loading capacity of the water body. EPA regulations define the loading capacity as the greatest amount of loading that a water body can receive without violating water quality standards. If the water body is not presently meeting its designated uses, then the loading capacity will represent a reduction relative to present loadings.

4. Specification of load allocations, based on the loading capacity determination, for non-point sources and point sources that will ensure that the water body will not violate water quality standards.

After public comment and final approval by the EPA, the TMDL will serve as a guide for future implementation activities. The MassDEP will work with the watershed towns of Dartmouth and New Bedford to develop specific implementation strategies to reduce N loadings, and will assist in developing a monitoring plan for assessing the success of the nutrient reduction strategies.

In the Slocums and Little Rivers embayment system the pollutant of concern for this TMDL (based on observations of eutrophication) is the nutrient nitrogen. Nitrogen is the limiting nutrient in coastal and marine waters, which means that as its concentration is increased so does plant productivity. This leads to nuisance populations of macro-algae and increased concentrations of phytoplankton and epiphyton which impairs the healthy ecology of the affected water bodies.

The TMDL for total N for the Slocums and Little Rivers Embayment System is based primarily on data collected, compiled and analyzed by University of Massachusetts Dartmouth's School of Marine Science and Technology (SMAST), the Southeast Regional Planning & Economic Development District and the Town of Dartmouth as part of the Massachusetts Estuaries Project (MEP). The data were collected over a study period from 2000 through 2006. This study period will be referred to as the "present conditions" in the TMDL since it contains the most recent data available. The accompanying MEP Technical Report (Howes *et al.* 2012*)* can be found at http://www.oceanscience.net/estuaries/reports.htm. The MEP Technical Report presents the results of the analyses of this coastal embayment system using the MEP Linked Watershed-Embayment N Management Model (Linked Model). The analyses were performed to assist the watershed communities with decisions on current and future wastewater planning, wetland restoration, anadromous fish runs, shellfisheries, open-space and harbor maintenance programs. A critical element of this approach is the assessment of water quality monitoring data, historical changes in eelgrass distribution, time-series water column oxygen measurements and benthic community structure that were conducted on this embayment. These assessments served as the basis for generating a N loading threshold for use as a goal for watershed N management. The TMDL is based on the site specific N threshold generated for this embayment. Thus, the MEP offers a science-based management approach to support the wastewater management planning and decision-making process in the watershed communities of Dartmouth and New Bedford.

Description of Water Bodies and Priority Ranking

The Slocums and Little Rivers Embayment System is located on the western shore of Buzzards Bay (See Figures 1 and 2). About 74.6% of the watershed of the Slocums River including the estuary portion is located within the Town of Dartmouth. The remaining approximately 25% of the northern portion of the watershed lies in the City of New Bedford. A very small percentage (<0.5%) lies also in the Towns of Westport and Freetown. The Slocums River is a tidal embayment with a number of streams, which flow into it. The mouth of the Slocums River embayment is defined by bedrock outcrops on the east at Potomska Point and by outcrops on the west in Lloyd State Park. The principal stream is the Paskamansett River (also spelled Paskamanset), which discharges into the northern headwaters and accounts for >80% of the surface water inflows. Other streams that discharge to the embayment include, in order of diminishing freshwater contribution: Destruction Brook; Barney's Joy River North and Barney's Joy River South/Giles Creek entering the estuary on the southwestern shore; and several relatively small, seasonal streams along both shores of the embayment.

The Town of Dartmouth has public water supply wells near the Paskamansett River. With a relatively large watershed and consequent substantial fresh surface water inputs, the Slocums River estuary has a variable salinity gradient that is strongly influenced by both short-term and seasonal rainfall patterns. Of the 23,771 acre watershed, more than 80% is north of the tidal reach of the estuary.

For the Slocums River and Little River Estuary System, the MEP project used 2009 land use data from the Town of Westport and the City of New Bedford, and 2010 data from the Town of Dartmouth. All land use data was provided by Buzzards Bay National Estuary Program (BBNEP) with subsequent review by the Town of Dartmouth staff. The predominant land use based on area in the Slocums River Estuary System watershed is public service/government, which accounts for 39% of the overall watershed area. Residential land area is the second highest percentage (30%). In the Little River system watershed, public service/government land uses (37%) and residential land uses (35%) are roughly equal. (See Figure IV-3 MEP Tech Report, Howes *et al.* 2012.)

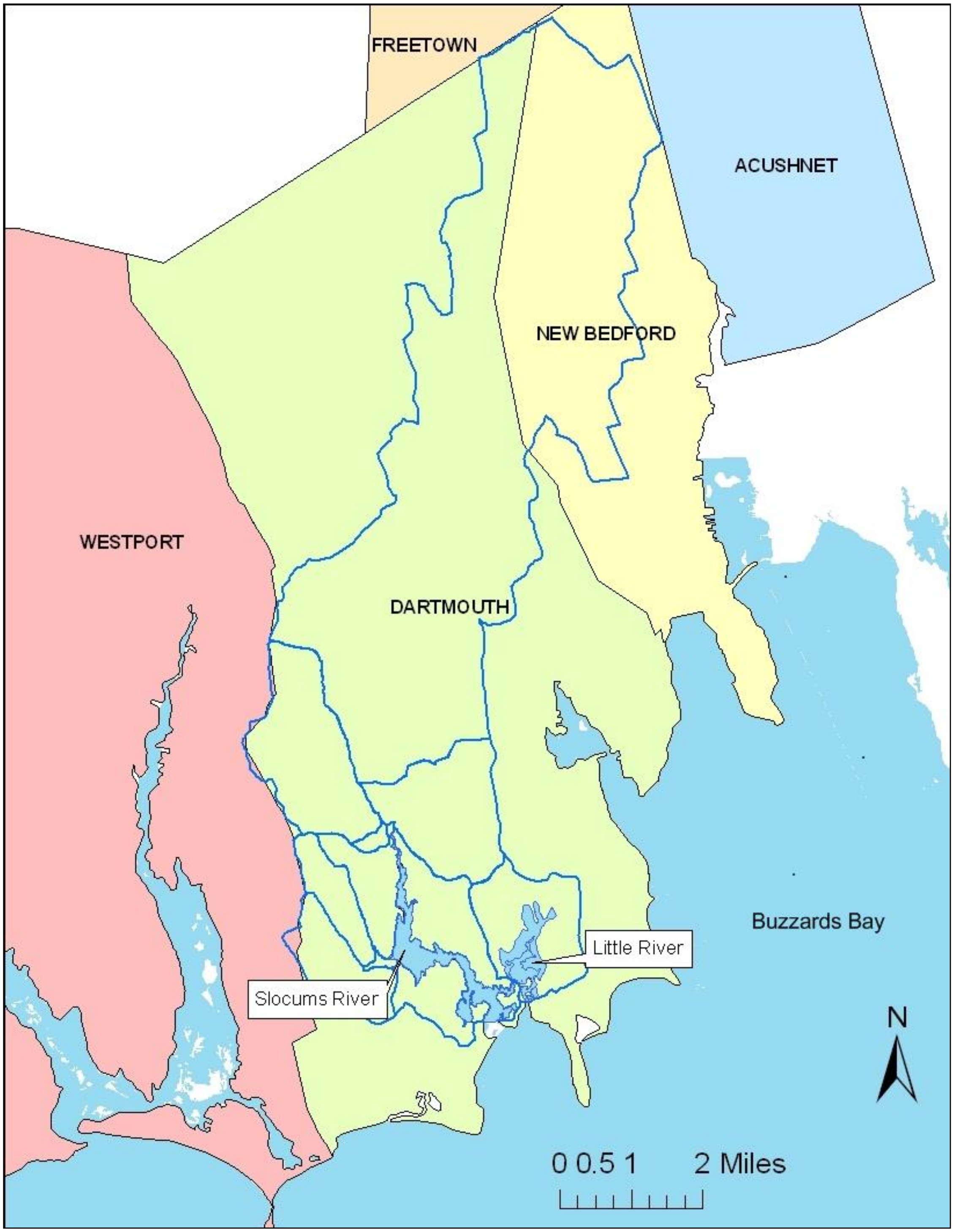


Figure 1 Watershed of the Slocums and Little Rivers Embayment System

There are a projected 2,009 additional residences at buildout in the Slocums River watershed. Buildout within the Slocum River watershed are projected to increase the unattenuated nitrogen loading rate by 15%. Buildout in the Little River watershed is predicted to increase the unattenuated nitrogen loading rate by 23%. (See Tables IV-6 and IV-7 of MEP Tech Report, Howes *et al.* 2012).

The Little River watershed and estuary is contained entirely within the Town of Dartmouth. The Little River embayment has a small watershed relative to its size, with 16.5 acres of land for each acre of estuary. Surface water inflow to the estuary is from two short intermittent streams that drain the low uplands to the northwest, while groundwater discharge is primarily to the extensive northern and eastern saltmarsh areas. The mouth of Little River is defined and controlled on the west by the bedrock outcrop of Potomska Point and on the east by both buried and partially exposed bedrock. There is a small amount of freshwater inflow, due to the small watershed relative to the surface area of estuary, and the relative "open" tidal exchange. The Little River shows little dilution of the salinity from the incoming Buzzards Bay waters and lower nutrient levels compared to the adjacent Slocums River waters. Currently, tidal exchange and thus potentially water quality of the Little River Estuary is linked in part to that of the Slocums River.

This embayment system constitutes an important component of the area’s natural and cultural resources. The nature of enclosed embayments in populous regions brings two opposing elements to bear: 1) as protected marine shoreline, they are popular regions for boating, recreation, and land development; and 2) as enclosed bodies of water, they may not be readily flushed of the pollutants that they receive due to the proximity and density of development near and along their shores. In particular, the Slocums River embayment is at risk of further eutrophication from high nutrient loads in the groundwater and runoff from their watersheds. The Slocums River and Little River are already listed as waters requiring a TMDL (Category 5) in the MA 2014 Integrated List of Waters, as summarized in Table 1. It is important to note however, that new data collected for the MEP study indicate that the Little River is not currently impaired by N.

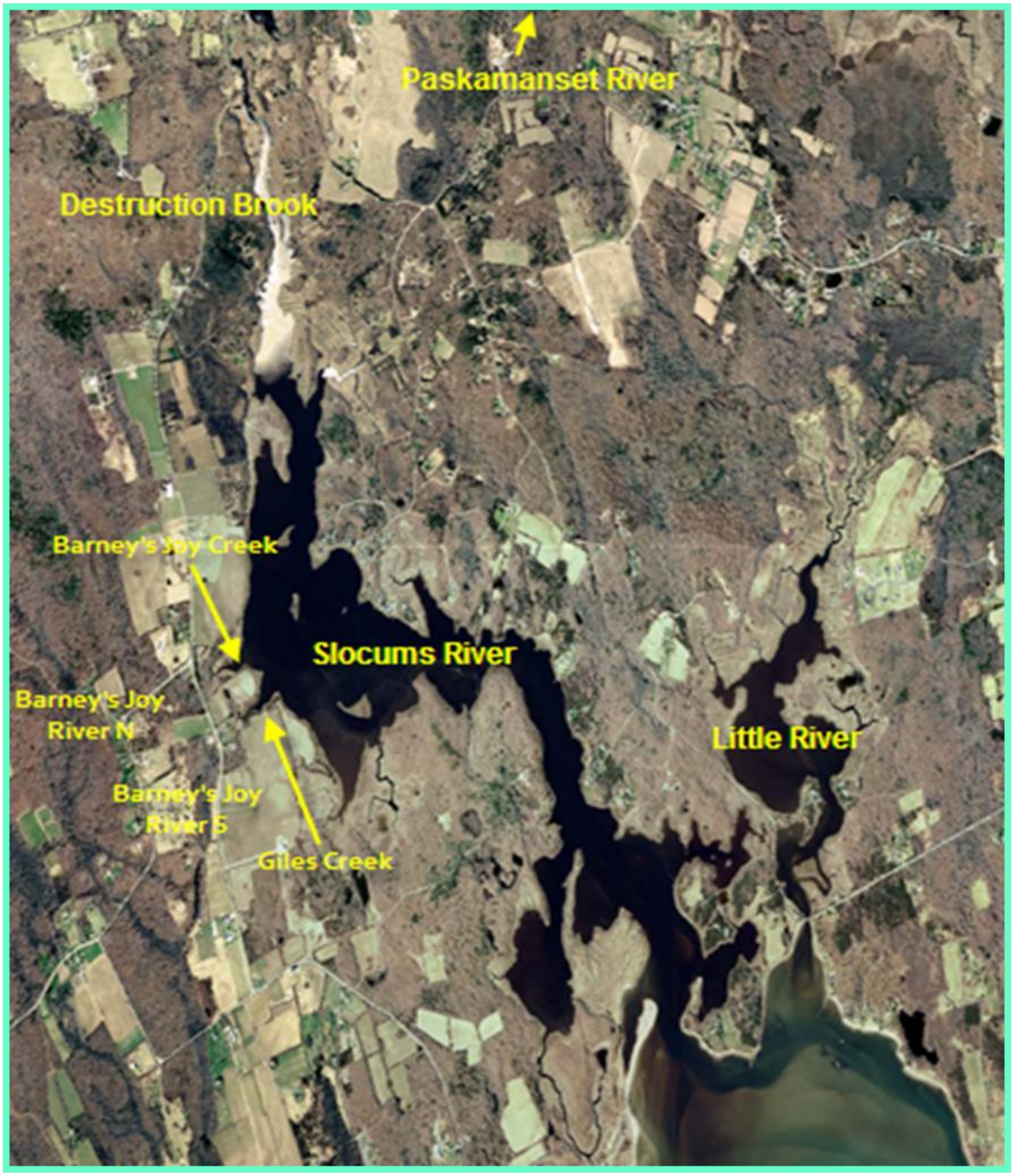

Paskamanset River
Destruction Brook
Barney's Joy Creek
Slocums River
Barney's Joy
River N
Barney's Joy
River S
Giles Creek
Little River

Table 1: Comparison of MassDEP and SMAST Impaired Parameters for Slocums and Little Rivers Water Body Segments Listed in Category 5 of the Massachusetts 2014 Integrated List of Waters

Name	Water Body Segment	Description	Size	DEP Listed Impaired Parameter[1]	SMAST Impaired Parameter[2]
Slocums River	MA95-34	Rock O'Dundee Road (confluence with Paskamansett River), Dartmouth to mouth at Buzzards Bay, Dartmouth	0.67 sq. mi. 23,430 acres	Total Nitrogen Pathogens, Estuarine Bioassessments	Total Nitrogen DO level Chlorophyll *a* Eelgrass loss Benthic fauna
Paskamansett River	MA95-11	Outlet Turners Pond Dartmouth/New Bedford to confluence with Slocums River	6,406 acres	No Uses Assessed	Total Nitrogen DO level Chlorophyll *a* Benthic fauna
Destruction Brook	MA95-90_2018	Outlet headwaters of Slocums River, Dartmouth	1,929 acres	No Uses Assessed	Total Nitrogen DO level Chlorophyll *a* Benthic fauna
Barneys Joy North		Outlet middle Slocums River under Barney's Joy Rd, north, Dartmouth	571 acres		Not impaired for nutrients
Barneys Joy South/Giles Creek		Outlet middle Slocums River under Barney's Joy Rd, south, Dartmouth	884 acres		Not impaired for nutrients
Little River	MA95-66	Dartmouth	0.18 sq. mi. 1,396 acres	Total Nitrogen	Not impaired for nutrients

[1] Water body segment is listed in Category 5 of the MA 2014 Integrated List of Waters
[2] As determined by the MEP Slocums and Little Rivers embayment study and reported in the Technical Report

A complete description of this embayment system is presented in Chapters I and IV of the MEP Technical Report (Howes *et al*. 2012). A majority of the information presented here on this embayment system is drawn from this report. Chapters VI and VII of the MEP Technical Report provide assessment data that show that the Slocums River system is impaired because of elevated total nitrogen, low dissolved oxygen levels, elevated chlorophyll *a* levels, loss of eelgrass and degraded benthic fauna habitat. Please note that pathogens and other habitat alterations are listed in Table 1 for completeness. Further discussion of pathogens or other habitat alterations is beyond the scope of this TMDL.

The embayments addressed by this document have been determined to be "high priority" based on three significant factors: (1) the initiative that the Town of Dartmouth has taken to assess the conditions of the entire embayment system; (2) the commitment made by the town to restore the Slocums and preserve the Little River; and (3) the extent of impairment in the Slocums system and the need to prevent future impairments of the Little River. In particular, the Slocums River embayment is at risk of further degradation from increased N loads entering through groundwater and surface water from the increasingly developed watershed. In both marine and freshwater systems, an excess of nutrients results in degraded water quality, adverse impacts to ecosystems and limits on the use of water resources. Observations are summarized in the Problem Assessment section below and detailed in Chapter VII, Assessment of Embayment Nutrient Related Ecological Health, of the MEP Technical Report.

Problem Assessment

The primary ecological threat to the Slocums and Little Rivers Embayment System is degradation resulting from nutrient enrichment. Water quality problems associated with development within the watersheds result primarily from septic systems, fertilizers, runoff and agricultural activities. Nitrogen from these sources washes directly into the surface waterbodies or enters the groundwater system and eventually connects with the surface waterbodies.

The water quality problems affecting nutrient-enriched embayments generally include periodic decreases of dissolved oxygen, loss of eelgrass habitat, decreased diversity and quantity of benthic animals, and periodic algae blooms. In the most severe cases habitat degradation could lead to periodic fish kills, unpleasant odors and scums and near loss of the benthic community and/or presence of only the most stress-tolerant species of benthic animals.

Coastal communities rely on clean, productive and aesthetically pleasing marine and estuarine waters for tourism, recreational swimming, fishing and boating, as well as commercial fin fishing and shell fishing. The continued degradation of this coastal embayment, as described above, will significantly reduce the recreational and commercial value and use of these important environmental resources.

Figure 3 shows how the population of Dartmouth has grown from roughly 9,000 people in 1940 to over 34,000 people in 2010. Increases in N loading to estuaries are directly related to increasing development and population in the watershed. Dartmouth's population has increased 375% in the past 70 years and an increase in population contributes to a decrease in forests and increases in septic systems, runoff from impervious surfaces and fertilizer use.

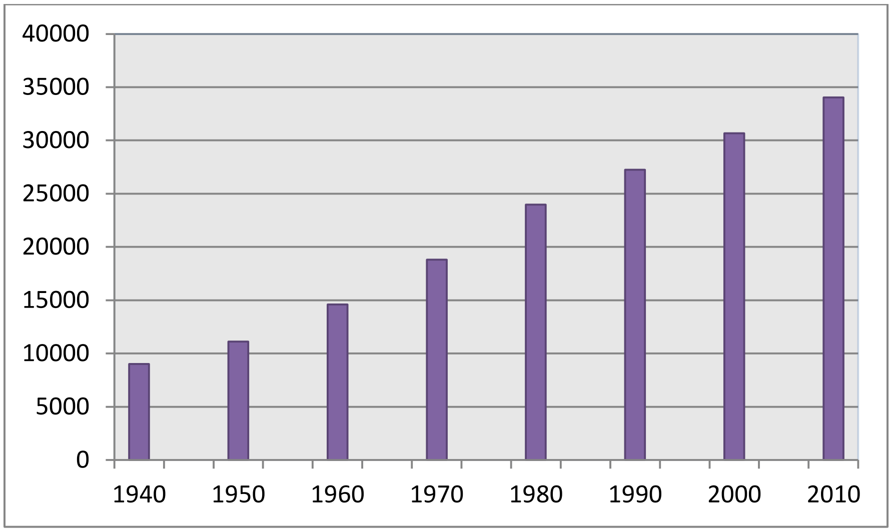


Figure 3: Resident Population for Dartmouth, 1940 through 2010

Habitat and water quality assessments were conducted on this embayment system based upon water quality monitoring data, changes in eelgrass distribution, time-series water column oxygen measurements and benthic community structure. The Slocums River system is a riverine estuary composed of an upper tidal river dominated by fringing wetlands, a large depositional basin in the middle of the system and a lower reach comprised of a main tidal channel and tributary coves, one of which is predominantly a salt marsh pond (Giles Creek). The Little River estuary is predominantly a salt marsh dominated tidal basin. Each of these functional components has different natural sensitivities to N enrichment and organic matter loading. Evaluation of eelgrass and infaunal habitat quality must consider the natural structure of each system and the system's ability to support eelgrass beds and various types of infaunal communities. At present, the Slocums and Little Rivers Estuarine System is showing variations in N enrichment and habitat quality among its various component basins (Table 2).

In general, the Slocums River system is showing healthy to moderately impaired benthic habitat within the upper tidal reach. As a wetland dominated basin, impairment in the upper tidal reach is only moderate resulting mainly from the patches of drift macroalgal accumulation and surface macrophyte mats. However, the middle basin is significantly impaired habitat for infaunal animals (with periodic fish kills), as a result of spatially distributed and significant accumulations of drift macroalgae, moderate to high chlorophyll-*a* levels and periodic oxygen depletions. The lower basin is generally supporting high quality infaunal habitat except in regions of macroalgal accumulation (likely transported from the middle basin). However, the lower basin is significantly impaired relative to eelgrass habitat. The lower basin historically supported eelgrass as indicated by the 1951 analysis by MassDEP and field data from 1985 but eelgrass beds are no longer present within the system. Based upon all evidence the Slocums River is presently impaired by N loading from its watershed and restoration of this estuary should focus on the impaired infauna habitat within the middle basin and eelgrass habitat within the lower basin.

Table 2: General Summary of Conditions Related to the Major Indicators of Habitat Impairment Observed in the Slocums and Little Rivers Embayment System

Embayment		Dissolved Oxygen Depletion	Eelgrass Loss	Chlorophyll *a*[1]	Benthic Fauna[2]	Macroalgae
Slocums River	Upper[3]	Salt marsh/Wetland Periodic depletions to <4 mg/L Very rare depletions to 3-2 mg/L **H**	**	High chlorophyll *a* levels generally >10-15 µg/L, frequently >20 µg/L (21% of time) **H-MI[3]**	Moderate numbers of individuals, moderate species, high diversity and Evenness **H**	Drift algae in sparse patches, patches of surface algal mat **H-MI**
Slocums River	Middle	Depletions periodically to <4 mg/L Infrequent declines to <3.5 mg/L **MI-SI**	**	High chlorophyll *a* levels generally 4-15 µg/L, >15 µg/L (15% of time) **SI**	Low to moderate numbers of species and individuals, low to moderate diversity and Evenness **SI**	Moderate to high accumulations of drift algae, primarily Ulva **SI**
Slocums River	Lower	Depletions periodically to <4 mg/L Infrequent declines to <3.5 mg/L **MI-SI**	Mapping indicates eelgrass lost from this system between 1951-1995 **SI**	Moderate to High chlorophyll *a* levels generally 5-10 µg/L Frequently >15 µg/L (8% of record) **MI-SI**	Tributary coves: moderately impaired habitat Main channel: high quality infaunal habitat, with high species diversity & evenness, high number of species & moderate number of individuals **H-MI**	Low accumulations of drift algae in tributary basins, little surface microphyte mat **H-MI**
Little River[3]		Salt marsh/Wetland Periodic depletions to <4 mg/L Very rare depletions to 3-2 mg/L **H**	**	Low to moderate chlorophyll *a* levels generally 2-8 µg/L, generally <6 µg/L **H**	Moderate to high number of individuals and species, with moderate to high diversity &evenness **H**	Diverse attached macroalgae community with some *Codium* and *Ruppia*, little drift algae **H**

[1]Algal blooms are consistent with chlorophyll *a* levels above 20 µg/l.
[2]Based on observations of the types of species, number of species, and number of individuals.
[3]Basin or estuarine reach supports fringing salt marsh and has a lower sensitivity to nitrogen enrichment and organic matter loading.
H - Healthy Habitat Conditions*
MI – Moderate Impairment*
SI – Significantly Impaired- considerably and appreciably changed from normal conditions*
SD – Severely Degraded – critically or harshly changed from normal conditions*
*- These terms are more fully described in MEP report "Site-Specific Nitrogen Thresholds for Southeastern Massachusetts Embayments: Critical Indicators" December 22, 2003 http://www.mass.gov/dep/water/resources/nitroest.pdf
** - No evidence this basin is supportive of eelgrass.

The Little River system is presently supporting high quality infaunal animal habitat and water quality conditions indicative of a salt marsh basin receiving watershed N inputs below its tolerance level. This system has infaunal communities consistent with a wetland dominated organic matter enriched estuarine sediment, with moderate to high numbers of individuals distributed among a diversity of species. The lower-most reach of this system is a tidal channel supporting the highest number of species within the entire Slocums and Little Rivers embayment system. The assessment of high quality infauna habitat is consistent with the generally low total N and chlorophyll-*a* levels, with oxygen depletion evident, but typical of salt marsh basins. Significantly, accumulations of drift macroalgae are not typical of this basin, with macroalgae present primarily as attached forms, e.g. *Codium, Enteromorpha*, and *Fucus*. There is no evidence that this estuarine river system ever supported eelgrass.

Pollutant of Concern, Sources, and Controllability

In the coastal embayments of the Town of Dartmouth, as in most marine and coastal waters, the limiting nutrient is N. Nitrogen concentrations beyond those expected naturally contribute to undesirable water quality and habitat conditions as described above in Table 1, through the promotion of excessive growth of plants and algae, including nuisance vegetation.

The embayments covered in this TMDL have had extensive data collected and analyzed through the Massachusetts Estuaries Program (MEP) and with the cooperation and assistance from Dartmouth, the USGS, and the Southeast Regional Economic and Development District. Data collection included both water quality and hydrodynamics as described in Chapters I, IV, V, VI and VII of the MEP Technical Report (Howes *et al*. 2012). These investigations revealed that loadings of N are much larger than would be under natural conditions.

Figure 4 illustrates the controllable sources of nitrogen to the Slocums and Little Rivers estuaries. The Slocums River watershed contributes over 97% of the total combined (Slocums and Little Rivers) controllable nitrogen load. In the Slocums River, most of the load originates from on-site subsurface wastewater disposal systems (septic systems) and runoff from impervious surfaces. Within the Slocums River watershed, the Paskamansett River and Destruction Brook subwatersheds are responsible for almost 93% of the nitrogen load.

The New Bedford Landfill is located within the Paskamansett River watershed east of Shawmut Avenue in New Bedford. Using the estimated total nitrogen concentrations, the digitized area of the capped solid waste (41 acres), and the Slocum River recharge rate, MEP staff developed an annual nitrogen load from the landfill of 2,128 kg. This total annual load is added to the watershed nitrogen load for the Paskamansett River subwatershed. The Dartmouth Landfill, also in the Slocums River watershed, was capped and a surface water drainage system was installed in 1996. Water quality data confirmed that the Dartmouth landfill is a negligible source of N.

In the Little River system septic systems are the major source of nitrogen. Although, freshwater wetlands are the largest single nitrogen source into both systems, this source is not considered controllable.

Figure 4a: Percent Contribution of Controllable Nitrogen Sources to the Slocums River System

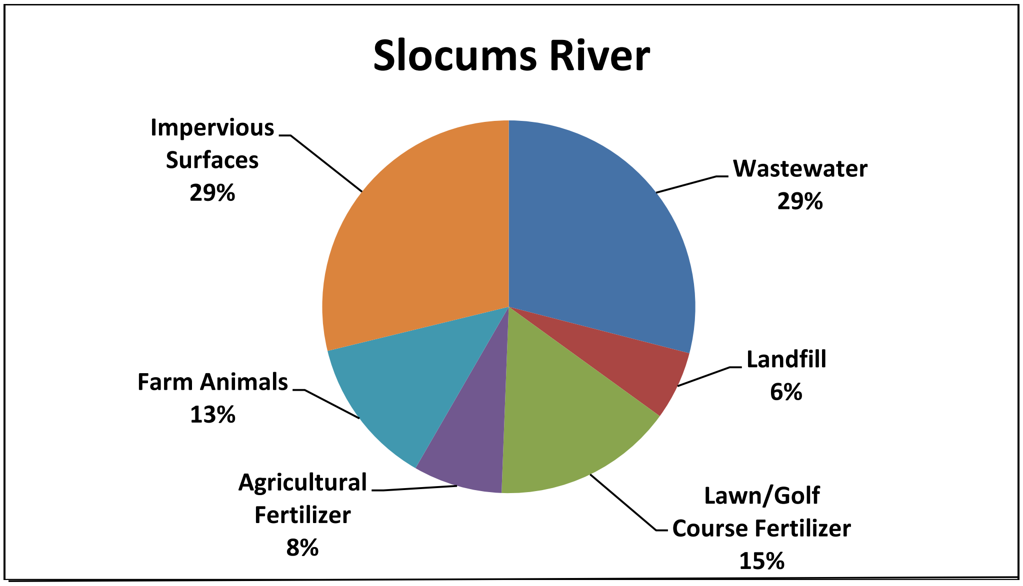
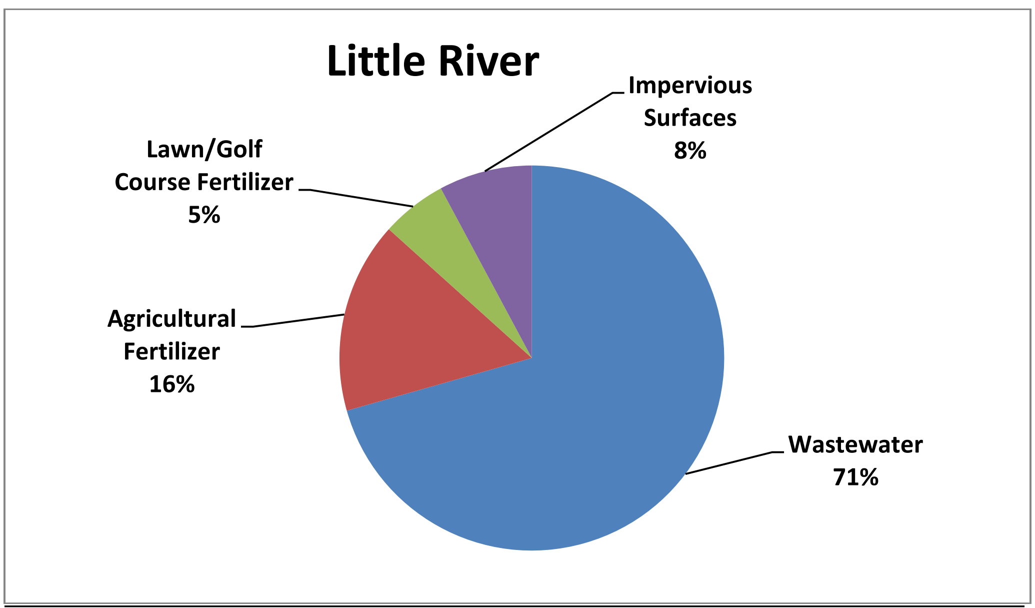


Figure 4b: Percent Contribution of Controllable Nitrogen Sources to the Little River System



The level of “controllability” of each source varies widely as seen below in Table 3. Cost/benefit analyses will have to be conducted on all possible N loading reduction methodologies in order to select the optimal control strategies, priorities and schedules.

Table 3: Sources of Nitrogen and their Controllability

Nitrogen Source	Degree of Controllability at Local Level	Reasoning
Agricultural fertilizer and animal wastes	Moderate	These nitrogen loadings can be controlled through appropriate agricultural Best Management Practices (BMPs).
Atmospheric deposition to the estuary surface	Low	It is only through region- and nation-wide air pollution control initiatives that significant reductions are feasible. Local control although helpful is not adequate.
Atmospheric deposition to natural surfaces (forests, fields, freshwater bodies) in the watershed	Low	Atmospheric deposition (loadings) to these areas cannot adequately be controlled locally. However, the N from these sources might be subjected to enhanced natural attenuation as it moves toward the estuary.
Fertilizer	Moderate	Lawn and golf course fertilizer and related N loadings can be reduced through BMPs, bylaws and public education.
Freshwater Wetlands	Low	Identified as a significant natural source of N in this system, which is characterized by extensive wetlands and swamps that border the river. Nitrogen is transformed in these wetlands but not attenuated due to the short hydraulic residence time in the associated river systems. It is not a controllable source.
Landfill	Low	Related N loadings can be controlled through appropriate BMP and management techniques.
Septic system	High	Sources of N can be controlled by a variety of case-specific methods including: sewering and treatment at centralized or decentralized locations, transporting and treating septage at treatment facilities with N removal technology either in or out of the watershed, or installing N-reducing on-site wastewater treatment systems.
Sediment	Low	N loadings are not feasibly controlled on a large scale by such measures as dredging. However, the concentrations of N in sediments, and thus the loadings from the sediments, will decline over time if sources in the watershed are removed, or reduced to the target levels discussed later in this document. In addition, increased dissolved oxygen will help keep N from fluxing.
Stormwater runoff from impervious surfaces	Moderate	This nitrogen source can be controlled by BMPs, bylaws and stormwater infrastructure improvements and public education. Stormwater NPDES permit requirements help control stormwater related N loadings in designated communities.
Wastewater treatment facility (WWTF)	High	Wastewater treatment facilities as point sources of pollution are permitted under the National Pollution Discharge Elimination System. Treated wastewater effluent discharged to groundwater disposal systems are permitted by MassDEP. There is a high degree of regulatory certainty that within the limits of technology, nutrient sources at these facilities can be controlled. The Dartmouth WWTF discharges to Buzzards Bay, not to Slocums and Little Rivers watershed.

Overview of the Applicable Water Quality Standards

The water quality classification of the saltwater portions of the Slocums and Little Rivers Embayment System is SA, and the freshwater portions of the system are classified as B. The transition to freshwater from marine is surface water not subject to tidal action or subject to mixing of fresh and ocean waters. Water quality standards of particular interest to the issues of cultural eutrophication are dissolved oxygen, nutrients, aesthetics, excess plant biomass and nuisance vegetation. The Massachusetts water quality standards (314 CMR 4.00) contain numeric criteria for dissolved oxygen but have only narrative standards that relate to the other variables. The narrative standards for nutrients (nitrogen and phosphorus) for waters of the Commonwealth are such that "all surface waters shall be free of nutrients in concentrations that would cause or contribute to impairment of existing or designated uses and shall not exceed site specific criteria developed in a TMDL or otherwise, established by the department" (MassDEP 2007).

Thus, the assessment of eutrophication is based on site-specific information within a general framework that emphasizes impairment of uses and preservation of a balanced indigenous flora and fauna. This approach is recommended by the U.S. Environmental Protection Agency in their draft Nutrient Criteria Technical Guidance Manual for Estuarine and Coastal Marine Waters (EPA-822-B-01-003, Oct 2001). The Guidance Manual notes that lakes, reservoirs, streams and rivers may be subdivided by classes, allowing reference conditions for each class and facilitating cost-effective criteria development for nutrient management. However, individual estuarine and coastal marine waters tend to have unique characteristics and development of individual water body criteria is typically required.

More details on the applicable standards can be found in Appendix A. This brief summary does not supersede or replace 314 CMR 4.0 Massachusetts Water Quality Standards, the official and legal standards. A complete version of 314 CMR 4.0 Massachusetts Water Quality Standards is available online at http://www.mass.gov/eea/agencies/massdep/water/regulations/314-cmr-4-00-mass-surface-water-quality-standards.html

Methodology - Linking Water Quality and Pollutant Sources

Extensive data collection and analyses have been described in detail in the MEP Technical Report. Those data were used by SMAST to assess the loading capacity of each sub-embayment. Physical (Chapter V), chemical and biological (Chapters IV, VII, and VIII) data were collected and evaluated. The primary water quality objective was represented by conditions that:

1) Restore the natural distribution of eelgrass because it provides valuable habitat for shellfish and finfish;
2) Prevent algal blooms;
3) Restore and preserve benthic communities;
4) Maintain dissolved oxygen concentrations that are protective of the estuarine communities.

The details of the data collection, modeling and evaluation are presented and discussed in Chapters IV, V, VI, VII and VIII of the MEP Technical Report. The main aspects of the data evaluation and modeling approach are summarized below.

The core of the Massachusetts Estuaries Project analytical method is the Linked Watershed-Embayment Management Modeling Approach. It fully links watershed inputs with embayment circulation and N characteristics, and is characterized as follows:

- Requires site specific measurements within the watershed and each sub-embayment;
- Uses realistic "best-estimates" of N loads from each land-use (as opposed to loads with built-in "safety factors" like Title 5 design loads);
- Spatially distributes the watershed N loading to the embayment;
- Accounts for N attenuation during transport to the embayment;
- Includes a 2D or 3D embayment circulation model depending on embayment structure;
- Accounts for basin structure, tidal variations, and dispersion within the embayment;
- Includes N regenerated within the embayment;
- Is validated by both independent hydrodynamic, N concentration, and ecological data;
- Is calibrated and validated with field data prior to generation of "what if" scenarios.

The Linked Model has been applied previously to watershed N management in over 60 embayments thus far throughout Southeastern Massachusetts. In these applications it became clear that the model can be calibrated and validated and has use as a management tool for evaluating watershed N management options.

The Linked Model, when properly calibrated and validated for a given embayment becomes a N management-planning tool as described in the model overview below. The model can assess solutions for the protection or restoration of nutrient-related water quality and allows testing of management scenarios to support cost/benefit evaluations. In addition, once a model is fully functional it can be refined for changes in land-use or embayment characteristics at minimal cost. Also, since the Linked Model uses a holistic approach that incorporates the entire watershed, embayment and tidal source waters, it can be used to evaluate all projects as they relate directly or indirectly to water quality conditions within its geographic boundaries. It should be noted that this approach includes high-order, watershed and sub-watershed scale modeling necessary to develop critical nitrogen targets for each major sub-embayment. The models, data and assumptions used in this process are specifically intended for the purposes stated in the MEP Technical Report, upon which this TMDL is based. As such, the Linked Model process does not contain the type of data or level and scale of analysis necessary to predict the fate and transport of nitrogen through groundwater from specific sources. In addition, any determinations related to direct and immediate hydrologic connection to surface waters are beyond the scope of the MEP's Linked Model process.

The Linked Model provides a quantitative approach for determining an embayment's (1) N sensitivity, (2) N threshold loading levels (TMDL) and (3) response to changes in loading rate. The approach is fully field validated and unlike many approaches, accounts for nutrient sources, attenuation and recycling and variations in tidal hydrodynamics (Figure I-2 of the MEP Technical Report). This methodology integrates a variety of field data and models, specifically:

• Monitoring - multi-year embayment nutrient sampling

• Hydrodynamics -
  - Embayment bathymetry (depth contours throughout the embayment)
  - Site-specific tidal record (timing and height of tides)
  - Water velocity records (in complex systems only)
  - Hydrodynamic model

• Watershed Nitrogen Loading
  - Watershed delineation
  - Stream flow (Q) and N load
  - Land-use analysis (GIS)
  - Watershed N model

• Embayment TMDL - Synthesis
  - Linked Watershed-Embayment Nitrogen Model
  - Salinity surveys (for linked model validation)
  - Rate of N recycling within embayment
  - Dissolved oxygen record
  - Macrophyte survey
  - Infaunal survey

Application of the Linked Watershed-Embayment Model

The approach developed by the MEP for applying the linked model to specific embayments, for the purpose of developing target N loading rates, includes:

1) Selecting one or two stations or sampling locations within the embayment system located close to the inland-most reach or reaches which typically has the poorest water quality within the system. These are called "sentinel" stations;

2) Using site-specific information and a minimum of three years of sub-embayment-specific data to select target threshold N concentrations for each sub-embayment. This is done by refining the draft target threshold N concentrations that were developed as the initial step of the MEP process. The target threshold N concentrations that were selected generally occur in higher quality waters near the mouth of the embayment system;

3) Running the calibrated water quality model using different watershed N loading rates to determine the loading rate that will achieve the target threshold N concentration at the sentinel station. Differences between the modeled N load required to achieve the target threshold N concentration and the present watershed N load represent N management goals for restoration and protection of the embayment system as a whole.

Previous sampling and data analyses and the modeling activities described above resulted in four major outputs that were critical to the development of the TMDL. Two outputs are related to N **concentration:**

1. The present N concentrations in the sub-embayments
2. Site-specific target threshold N concentrations

And, two outputs are related to N **loadings:**

1. The present N loads to the sub-embayments
2. Load reductions necessary to meet the site specific target N concentrations

In summary: meeting the water quality standards by reducing the N concentration (and thus the N load) at the sentinel station(s), the water quality goals will be met throughout the entire system.

A brief overview of each of the outputs follows:

Nitrogen concentrations in the embayment

a) Observed "present" conditions:
Table 4 presents the average concentrations of N measured in this embayment from six years of data collected at up to 12 stations during the period 2000 through 2006. The overall means and standard deviations of the averages are presented in Appendix A (reprinted from Table VI-1 of the accompanying MEP Technical Report). Water quality sampling stations are shown in Figure 5 below.

b) Modeled site-specific target threshold N concentrations:
The target threshold N level for an embayment represents the average water column concentration of N that will support the habitat quality and dissolved oxygen concentrations being sought. The water column N level is ultimately controlled by the integration of the watershed N load, the N concentration in the inflowing tidal waters (boundary condition), and dilution and flushing via tidal flows. The water column N concentration is modified by the extent of sediment uptake and/or regeneration, by direct atmospheric deposition and phytoplankton uptake.

A major component of TMDL development is the determination of the maximum concentrations of N (based on field data) that can occur without causing unacceptable impacts to the aquatic environment. Prior to conducting the analytical and modeling activities described above, SMAST selected appropriate nutrient-related environmental indicators and tested the qualitative and quantitative relationship between those indicators and N concentrations. The Linked Model was then used to determine site-specific target threshold N concentrations by using the specific physical, chemical and biological characteristics of each sub-embayment.

Target threshold N levels were developed to restore or, in the case of the Little River estuary, maintain SA waters or high habitat quality. In these embayments, high habitat quality was defined as healthy eelgrass beds (in the Slocums River only), diverse benthic animal communities and dissolved oxygen levels that would support Class SA waters. The findings of the analytical and modeling investigations to determine this target threshold nitrogen concentration for the embayment system are discussed below.

Table 4: Observed Present Nitrogen Concentrations and Sentinel Station Threshold Nitrogen Target Concentrations for the Slocums and Little Rivers System

Sub-embayment	Observed Nitrogen Concentration [1] (mg/L)	Sentinel Station Target Threshold Nitrogen Concentration (mg/L)
Upper Slocums River	0.64	
Mid Slocums River	0.40 –0.62[2]	
Lower Slocums River	0.39	0.36 (Near station SRT-12)
Paskamansett River	0.93[3]	
Destruction Brook	1.50[3]	
Barney's Joy River (North & South)	0.61[3]	
Little River	0.40	0.50 [4] (Near station SRT-15)

[1] Calculated as the average of the separate yearly means of 2000-2006 data. Overall means and standard deviations of the average are presented in Appendix B.

[2] Listed as a range since it was sampled at several stations (see Appendix B)

[3] MEP stream gage data as reported in Table IV-8 of the MEP Technical Report.

[4] The target threshold N level is higher than the present conditions because Little River is not impaired and is functioning as a salt marsh so it is capable of receiving a higher nitrogen load

In the Slocums River system the loss of eelgrass classifies the lower tidal reach as "significantly impaired" although it presently supports healthy to moderately healthy infaunal communities. The target nitrogen concentration (tidally averaged N) for restoration of eelgrass at the sentinel location at Station SRT-12 (Figure 5) within the lower reach of the Slocums River was determined to be 0.36 mg/L N (Table 4).

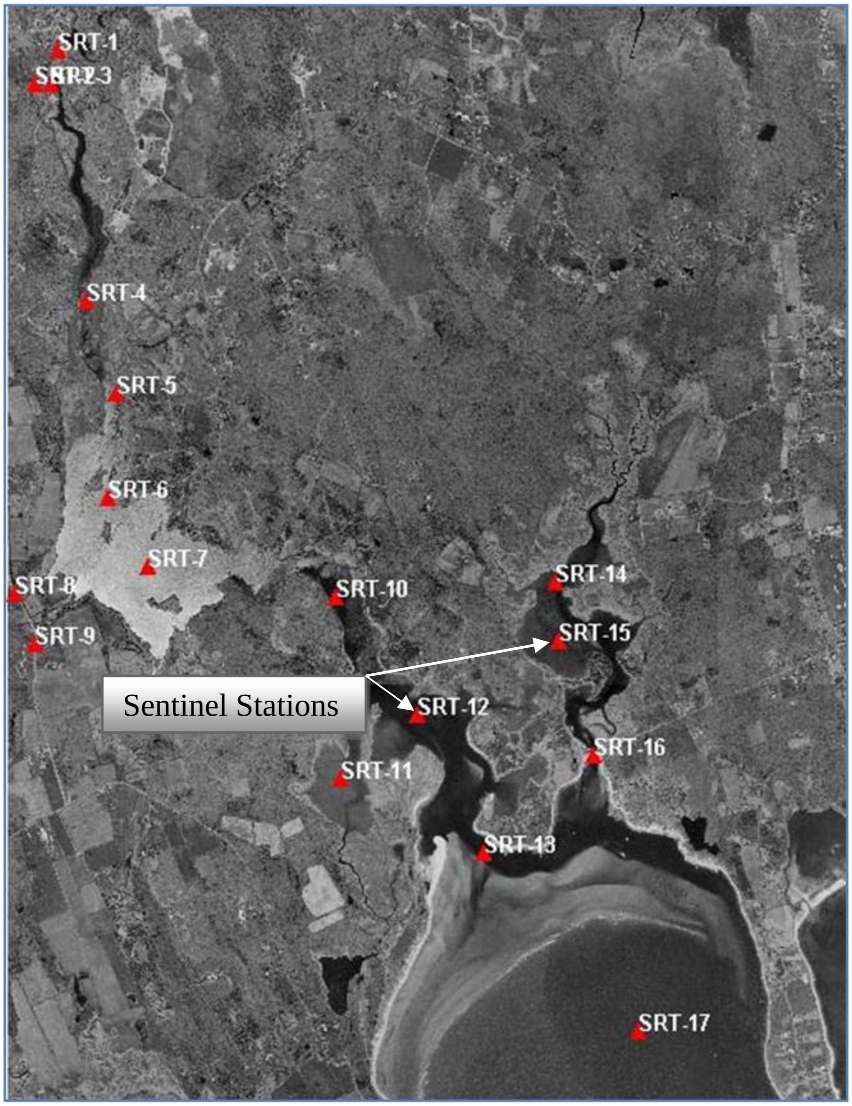


Figure 5: Water Quality Sampling Stations in the Slocums and Little Rivers Estuaries.

Since there is no eelgrass within this estuary the MEP study determined the target threshold nitrogen concentration upon comparison to other local embayments of similar depths and structure. A well studied eelgrass bed within the lower Oyster River in Chatham has been stable at a tidally averaged water column N of 0.37 mg/L N, while eelgrass was lost within the Lower Centerville River at a tidally averaged N of 0.395 mg/L N and also within Waquoit Bay at 0.39 mg/L N. Although the nitrogen management target is restoration of eelgrass habitat, benthic infaunal habitat quality must also be supported as a secondary condition. Therefore, in addition to the primary target nitrogen threshold at the sentinel station, secondary criteria for infaunal habitat restoration was established by the MEP study to ensure that all impaired regions are restored if the threshold at the sentinel station is achieved. The infaunal check station is the long-term average TN of stations SRT-6 and SRT-7 located within the presently significantly impaired middle basin. The tidally averaged target threshold nitrogen level required at this station to restore the infaunal animal habitat throughout the Slocums River system is <0.5 mg/L

N based on comparison with other nearby, similar estuaries where levels <0.5 mg/L N were found to be supportive of healthy infaunal habitat. Watershed nitrogen management to achieve this "check" nitrogen level will ensure restoration of infaunal habitats within the down-gradient reach as well. The secondary criteria should also be met when the target threshold is met at the sentinel station. Based on this, eelgrass is the primary nitrogen management goal for the lower Slocums River system and infaunal habitat quality the management target for the upper reaches.

The Little River does not support eelgrass nor is there any evidence that it ever had. The absence of eelgrass in similar saltmarsh dominated basins is typical throughout Southeastern Massachusetts. As a result, management of the Little River estuary should focus on maintaining the current high level of infaunal habitat quality. Since the Little River system is presently supporting high quality habitat and low total nitrogen levels and is predominately a salt marsh basin, its nitrogen threshold level is higher than the present condition of watershed nitrogen loading. A conservative estimate of the target threshold nitrogen level for this system of 0.5 mg/L N at the sentinel location (Station SRT-15, shown in Figure 5) is based on comparison to other nearby estuaries where levels <0.5 mg/L N were found to be supportive of healthy infaunal habitat (Table 2). However the goal should be to maintain the existing quality and prevent further degradation.

The findings of the analytical and modeling investigations for this embayment system are discussed and explained below.

Nitrogen loadings to the embayment

a) Present Loading rates:

In the Slocums and Little Rivers embayment systems overall the highest N loading from controllable sources is from on-site wastewater treatment systems (30 kg/day N) with runoff from impervious surfaces a close second (28 kg/day N). Agricultural activities, including farm animals contributed about 20 kg/day N and fertilizers from lawns and golf courses combined accounted for about 15 kg/day of N. The N load from the landfill in the Paskamansett subwatershed contributed about 6 kg/day. Nitrogen rich sediments in this system are a minor contribution. However, reducing the N load to the estuary will also reduce N in the sediments since the magnitude of the benthic contribution is related to the watershed load.

The total attenuated N loading from all sources is 154.78 kg/day across Slocums and Little Rivers embayments. A further breakdown of N loading, by source, is presented in Table 5. The data on which Table 5 is based can be found in Table ES-1 of the MEP Technical Report.

As previously indicated, the present N loadings to the Slocums River embayment system must be reduced in order to restore the impaired conditions and to avoid further nutrient-related adverse environmental impacts. The critical final step in the development of the TMDL is modeling and analysis to determine the loadings required that will achieve the target threshold N concentrations.

b) Nitrogen loads necessary for meeting the site-specific target threshold N concentrations:

The nitrogen thresholds developed by SMAST (Section VIII.2 in the MEP Technical Report) and summarized above were used to determine the amount of total nitrogen mass loading reduction required for restoration of eelgrass and infaunal habitats in the Slocums River system and protection of infaunal habitat in the Little River estuary. Tidally averaged total nitrogen thresholds were used to adjust the calibrated water quality model (Section VI in the MEP Technical Report). Watershed nitrogen loads were sequentially lowered using reductions in septic effluent discharges only until the nitrogen levels reached the threshold level at the sentinel station chosen for Slocums River (SRT-12). It is important to note that load reductions can be produced by reduction of any or all sources of N and/or by increasing the natural attenuation of nitrogen within the freshwater systems to the embayment. The load reductions presented here represent only one of a suite of potential reduction approaches that need to be evaluated by the community.

Table 5: Present Attenuated Nitrogen Loadings to the Slocums and Little Rivers System

Sub-Embayment	Present Non-Wastewater Watershed Load[1] (kg N/day)	Present Septic System Load (kg N/day)	Present Atmospheric Deposition[2] (kg N/day)	Present Benthic Input (kg N/day)[3]	Total nitrogen load from all sources [4] (kg N/day)
Slocums River	5.19	2.37	6.16	-4.87	8.85
Paskamansett River & Destruction Brook	103.12	16.88	--	--	120.0
Barney's Joy River (North & South)	6.40	1.13	--	--	7.53
Little River	6.38	1.76	1.36	8.90	18.4
System Total	121.09	22.15	7.52	4.03	154.78

[1]Includes fertilizers, runoff, landfill, farm animals, and atmospheric deposition to lakes, wetlands and natural surfaces. [2] Atmospheric deposition to the estuarine surface only. [3] Nitrogen loading from sediments.
[4] Composed of fertilizer, agriculture, runoff, landfill, wastewater, atmospheric deposition, and benthic nitrogen input.

Table 6 presents the present and target threshold watershed N loading to the Slocums and Little Rivers systems and the percent reduction of N necessary to meet the target threshold N concentration at the sentinel station (SRT-12) (from Table ES-2 of the MEP Technical Report). The water and habitat quality of the Little River and Barney's Joy River are presently considered to be "healthy" and no reductions of N loading are called for. However, this document serves to notify the Town of Dartmouth that the current N loading rates to these two systems are protective and should be maintained as closely as possible in order to prevent future impairments.

It is very important to note that load reductions can be produced through a variety of strategies, including: reduction of any or all sources of N; increasing the natural attenuation of N within the freshwater systems; and/or modifying the tidal flushing through inlet reconfiguration (where appropriate). This scenario presented here establishes the general degree and spatial pattern of reduction that will be required for restoration of the N impaired portions of the Slocums River Estuarine System. The watershed communities should take any reasonable actions to reduce the controllable N sources.

Table 6: Present Watershed Nitrogen Loading Rates, Calculated Loading Rates that are Necessary to Achieve Target Threshold Nitrogen Concentrations, and the Percent Reductions of the Existing Loads Necessary to Achieve the Target Threshold Loadings.

Sub-embayment	Present Total Watershed Load [1] (kg N/day)	Target Threshold Watershed Load[2] (kg N/day)	Percent Watershed Load Reductions Needed to Achieve Target
Slocums River	7.56	5.76	- 23.8%
Paskamansett River & Destruction Brook	120.0	106.5	- 11.3%
Barney's Joy River (North & South)	7.53	7.53	0%
Little River	8.14	8.14	0%
System Total	143.24	127.93	- 10.7%

[1] Composed of fertilizer, runoff, landfill, farm animals, atmospheric deposition to lakes and natural surfaces and septic system loadings.
[2] Target threshold watershed load is the N load from the watershed (including natural background) needed to meet the target threshold N concentrations identified in Table 4, above.

Table 7 (from Table VIII-2 of the MEP Technical Report) presents a more specific load reducing scenario that would be necessary to achieve the target threshold N concentration at the sentinel station in the Slocums River (SRT-12) based solely on reducing the septic loads from the Slocums, Paskamansett River and Destruction Brook watersheds. However, as previously noted, there are a variety of loading reduction scenarios that could achieve the target threshold N concentrations. Local officials can explore other loading reduction scenarios through additional modeling as part of their Comprehensive Wastewater Management Plan (CWMP). It must be demonstrated however, that any alternative implementation strategies will be protective of the entire embayment system. To this end, additional linked model runs can be performed by the MEP to assist the planning efforts of the town in achieving target N loads that will result in the desired target threshold N concentration.

Table 7: Summary of the Present Septic System Loads, and the Loading Reductions Necessary to Achieve the TMDL by Reducing Septic System Loads Only

Sub-embayment	Present Septic Load (kg/day)	Threshold Septic Load (kg/day)	Threshold Septic Load % Change
Slocums River[1]	2.37	0.570	-76%
Little River[1]	1.76	1.76	0
Surface Water Sources:			

Paskamansett River and Destruction Brook	16.88	3.375	-80%
Barneys Joy River (North and South)	1.13	1.13	0
System Total	22.15	6.84	- 69%

[1]Total estuarine reach which receives septic N inputs through direct groundwater discharge and from surface water (stream) inflows.

Total Maximum Daily Loads

As described in EPA guidance, a total maximum daily load (TMDL) identifies the loading capacity of a water body for a particular pollutant. EPA regulations define loading capacity as the greatest amount of loading that a water body can receive without violating water quality standards. A TMDL is established to protect and/or restore the estuarine ecosystem, including eelgrass, the leading indicator of ecological health, thus meeting water quality goals for aquatic life support. Because there are no "numerical" water quality standards for N, the TMDLs for the Slocums and Little Rivers Embayment System are aimed at establishing the loads that would correspond to specific N concentrations determined to be protective of the water quality and ecosystems.

The TMDL development process includes detailed analyses and mathematical modeling of land use, nutrient loads, water quality indicators, and hydrodynamic variables (including residence time) for each sub-embayment. The results of the mathematical model are correlated with estimates of impacts on water quality, including negative impacts on eelgrass (the primary indicator), as well as dissolved oxygen, chlorophyll-*a* and benthic infauna.

In general, the TMDL can generally be defined by the equation:

$$TMDL = BG + WLAs + LAs + MOS$$

Where:

TMDL = loading capacity of receiving water
BG = natural background
WLAs = Waste Load Allocation is the portion allotted to point sources
LAs = Load Allocation portion is allotted to (cultural) non-point sources
MOS = margin of safety

Background Loading

Natural background N loading is included in the loading estimates, but is not quantified or presented separately. Background loading was calculated on the assumption that the entire watershed is forested with no anthropogenic sources of N. It is accounted for in this TMDL but not defined as a separate component. Readers are referred to Table ES-1 of the MEP Technical Report for estimated loading due to natural conditions.

Waste Load Allocations

Waste load allocations (WLA) identify the portion of the loading capacity allocated to existing and future point sources of wastewater. A TMDL may establish a specific WLA for an identified source or, as in the case of stormwater, may establish an aggregate WLA that applies to numerous sources. EPA interprets 40 CFR 130.2(h) to require that allocations for NPDES regulated discharges of storm water be included in the waste load component of the TMDL.

Consequently, there are areas of the Slocums and Little Rivers watershed in New Bedford and Dartmouth (as well as a small area of Freetown) that contain EPA designated "urbanized areas" and as such are required to obtain coverage under the NPDES Phase II General Permit for stormwater discharges from Small Municipal Separate Storm Sewer Systems (MS4s). In addition, there are directly connected impervious areas (DCIAs) throughout the entire watershed as identified by the EPA in: http://www.epa.gov/region1/npdes/stormwater/ma.html that discharge stormwater directly to waterbodies via a conveyance system such as a swale, pipe or ditch. This TMDL treats stormwater discharge from all DCIA (even those outside of regulated urbanized areas) as part of a waste load allocation. Since there are no other point sources of nitrogen in the Slocums and Little Rivers watershed the DCIA stormwater load contribution is considered the total waste load allocation for the TMDL.

The Linked Model accounts for storm-water and groundwater loadings in one aggregate allocation as a non-point source – combining the assessments of waste water and storm-water (including stormwater that infiltrates into the soil and direct discharge pipes into water bodies) for the purpose of developing control strategies. Based on land use, the Linked Model accounts for loading from stormwater, but does not differentiate stormwater into a load and waste load allocation. In order to distinguish the point source or waste load allocation of stormwater originating from DCIAs from the nonpoint source stormwater contribution (LA or load allocation), the percent of the impervious area that was identified as DCIA was determined and multiplied by the impervious surface N load (in kg N/day) as reported by the MEP in Table IV-6 of the Technical Report.

Table 8 shows the existing WLA and LA from stormwater runoff from impervious surfaces in the watershed of the Slocums and Little Rivers system. Percentages of DCIA in the subwatersheds were determined from the town by impervious area statistics listed on the EPA NPDES Stormwater Regulated Communities website:
http://www.epa.gov/region1/npdes/stormwater/ma.html. The WLAs for stormwater nitrogen contribution (kg N/day) was determined using the DCIA for each subembayment divided by total impervious area in the subembayment, then multiplying the total impervious surfaces runoff N load for the subwatershed (from Table IV-6 in the MEP Technical Report) per EPA (EPA, 2010) Methodology. The remaining impervious surfaces loads were assigned as the LA.

For example, the impervious surface N load in the Paskamansett and Destruction Brook subwatersheds is 27 kg N/day (from Table IV-6 in the MEP Technical Report). This load was multiplied by the percent DCIA in those subwatersheds (67%) as calculated from the EPA stormwater link, to get the stormwater WLA of 18.07. As evident in Table 7, the Paskamansett, Destruction Brook subwatershed contributes the majority (97%) of the stormwater N load to the entire system compared to the other subwatersheds and 67% of this load is attributed to point sources of stormwater from directly connected impervious areas (the WLA).(See Appendix C for impervious cover statistics for each subwatershed as well as example calculations for determining the stormwater nitrogen WLA.)

Table 8. Existing Stormwater WLA and LA as determined by Percentage of Directly Connected Impervious Area (DCIA) in the watershed of the Slocums and Little Rivers Watershed

Subwatershed	% DCIA[1]	Impervious Surface N Load[2] (kg N/day)	Stormwater WLA[3] kg N/day	Stormwater LA kg N/day
Slocums River	1%	0.52	0.005	0.51
Little River	1%	0.2	0.002	0.198
Paskamansett/ Destruction Bk.	67%	27	18.07	8.93
Barneys Joy River North	1%	0.08	0.001	0.079
Barneys Joy River South	1%	0.19	0.002	0.188
System Total		27.9	18.08	9.905

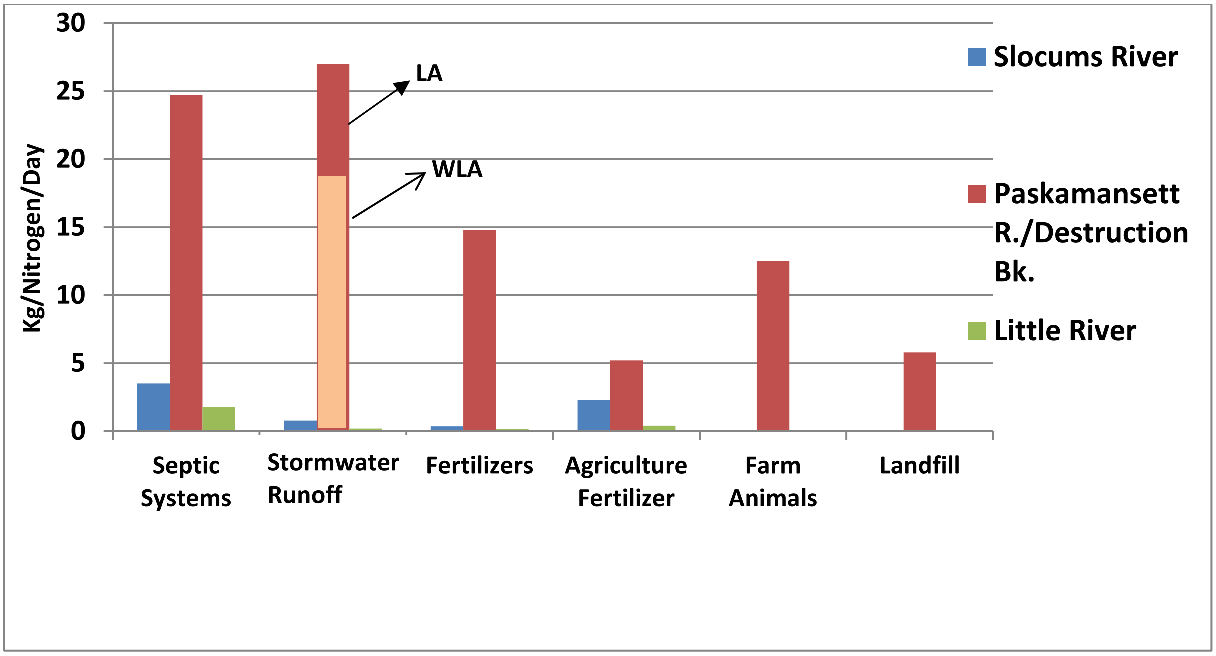
from http://www.epa.gov/region1/npdes/stormwater/ma.html
[1] DCIA (Directly connected impervious area in acres) divided by Total Area (acres) X 100.
[2]from the MEP Technical Report, Table IV-6
[3]Percent DCIA multiplied by Impervious Surface N Load (e.g., Slocums River WLA = 0.01X 0.52 = 0.005)

Load Allocations

Load allocations (LA) identify the portion of loading capacity allocated to existing and future nonpoint sources. In the case of the Slocums and Little Rivers embayment system the nonpoint source loadings are primarily from septic systems although nearly as much has been attributed to agricultural activities, fertilizers and stormwater runoff from impervious surfaces not previously accounted for as a point source coming from DCIA. Figure 6 shows a breakdown of the N contributions from each source and also shows the contributions from both the WLA and LA portions of the stormwater load into the Paskamansett and Destruction Brook subwatershed. Additional non-point N sources include the landfill, natural background, atmospheric deposition, and nutrient-rich sediments. Nitrogen from stormwater runoff attributed to impervious surfaces not directly connected to a waterbody was determined to be 9.9 kg/day for the entire watershed (see Table 8) which, when compared to the total impervious surfaces N watershed load of 27.8, accounts for approximately 36% of the impervious surfaces N load for the entire watershed.

Locally controllable sources of N within the watershed are categorized as on-site subsurface wastewater disposal system wastes, runoff from impervious surface, fertilizers, agriculture, farm animals, and the landfill. Figure 6 below illustrates that septic systems and impervious surfaces are a significant portion of the controllable N load. Septic systems contribute 30 kg/day of N to the total estuary system while runoff from impervious surfaces contributes 27.9 kg N/day. The Paskamansett subwatershed is by far the largest contributor to the N loadings in every land use category. These figures emphasize the fact that both septic systems and impervious surface are areas where reduction could take place although reductions in fertilizers and contributions from agricultural activities (including farm animals) would also benefit the overall goal.

Figure 6: Slocums River, Paskamansett/Destruction Brook and Little River Subwatersheds Controllable N Sources



Benthic Flux and Atmospheric Deposition

The sediment loading rates incorporated into the TMDL are lower than the existing benthic input listed in Table 5 above because projected reductions of N loadings from the watershed will result in reductions of nutrient concentrations in the sediments and therefore, over time, reductions in loadings from the sediments will occur. Benthic flux of nitrogen from bottom sediments is a critical (but often overlooked) component of nitrogen loading to the shallow estuarine systems, therefore determination of the site specific magnitude of this component was also performed (see Section VI of the MEP Report). Benthic N flux is a function of N loading and particulate organic N (PON). Projected benthic fluxes are based upon projected PON concentrations and watershed N loads and are calculated by multiplying the present N flux by the ratio of projected PON to present PON using the following formulae:

Projected N flux = (present N flux) (PON projected / PON present)

When: $PON\ projected = (R_{load})\ (D_{PON})\ +\ PON_{present\ offshore}$

$When\ R_{load} = (projected\ N\ load) / (Present\ N\ load)$

And D_{PON} is the PON concentration above background determined by:

$D_{PON} = (PON_{present\ embayment} - PON_{present\ offshore})$

The benthic flux modeled for the Slocums and Little Rivers embayment system is reduced from existing conditions based on the load reduction and the observed PON concentrations within each sub-embayment relative to Buzzards Bay (boundary condition). The benthic flux input to each sub-embayment was reduced (toward zero) based on a future reduction of N in the watershed load.

The loadings from atmospheric sources incorporated into the TMDL however, are the same rates presently occurring because, as discussed above, local control of atmospheric loadings is not considered feasible.

Margin of Safety

Statutes and regulations require that a TMDL include a margin of safety (MOS) to account for any lack of knowledge concerning the relationship between load and wasteload allocations and water quality [CWA para 303 (d)(20,(c) 40C.G.R. para 130.7(c)(1)]. The EPA's 1991 TMDL Guidance explains that the MOS may be implicit, i.e., incorporated into the TMDL through conservative assumptions in the analysis, or explicit, i.e., expressed in the TMDL as loadings set aside for the MOS. The MOS for the Slocums and Little Rivers Embayment System TMDL is implicit and the conservative assumptions in the analyses that account for the MOS are described below. An explicit MOS quantifies an allocation amount separate from other Load and Wasteload Allocations. An explicit MOS can incorporate reserve capacity for future unknowns, such as population growth or effects of climate change on water quality. An implicit MOS is not specifically quantified but consists of statements of the conservative assumptions used in the analysis. The MOS for the Slocums and Little Rivers Embayment System TMDL is implicit. MassDEP used conservative assumptions to develop numeric model applications that account for the MOS. These assumptions are described below, and they account for all sources of uncertainty, including the potential impacts of changes in climate.

While the general vulnerabilities of coastal areas to climate change can be identified, specific impacts and effects of changing estuarine conditions are not well known at this time (http://www.mass.gov/eea/waste-mgnt-recycling/air-quality/green-house-gas-and-climate-change/climate-change-adaptation/climate-change-adaptation-report.html). Because the science is not yet available, MassDEP is unable to analyze climate change impacts on streamflow, precipitation, and nutrient loading with any degree of certainty for TMDL development. In light of these uncertainties and informational gaps, MassDEP has opted to address all sources of uncertainty through an implicit MOS. MassDEP does not believe that an explicit MOS approach is appropriate under the circumstances or will provide a more protective or accurate MOS than the implicit MOS approach, as the available data simply does not lend itself to characterizing and estimating loadings to derive numeric allocations within confidence limits. Although the implicit MOS approach does not expressly set aside a specific portion of the load to account for potential impacts of climate change, MassDEP has no basis to conclude that the conservative assumptions that were used to develop the numeric model applications are insufficient to account for the lack of knowledge regarding climate change.

Conservative assumptions that support an implicit MOS:

1. Use of conservative data in the linked model

The watershed N model provides conservative estimates of N loads to the embayment. Nitrogen transfer through direct groundwater discharge to estuarine waters is based upon studies indicating negligible aquifer attenuation and dilution, i.e. 100% of load enters embayment. This is a conservative estimate of loading because studies have also shown that in some areas less than 100% of the load enters the estuary. Nitrogen from the upper watershed regions, which travel through ponds or wetlands, almost always enter the embayment via stream flow, are directly measured (over 12-16 months) to determine attenuation. In these cases the land-use model has shown a slightly higher predicted N load than the measured discharges in the streams/rivers that have been assessed to date. Therefore, the watershed model as applied to the surface water watershed areas again presents a conservative estimate of N loads because the actual measured N in streams was lower than the modeled concentrations.

The hydrodynamic and water quality models have been assessed directly. In the many instances where the hydrodynamic model predictions of volumetric exchange (flushing) have also been directly measured by field measurements of instantaneous discharge, the agreement between modeled and observed values has been >95%. Field measurement of instantaneous discharge was performed using acoustic doppler current profilers (ADCP) at key locations within the embayment (with regards to the water quality model, it was possible to conduct a quantitative assessment of the model results as fitted to a baseline dataset - a least squares fit of the modeled versus observed data showed an R2>0.95, indicating that the model accounted for 95% of the variation in the field data). Since the water quality model incorporates all of the outputs from the other models, this excellent fit indicates a high degree of certainty in the final result. The high level of accuracy of the model provides a high degree of confidence in the output; therefore, less of a margin of safety is required.

In the case of N attenuation by freshwater ponds, attenuation was derived from measured N concentrations, pond delineations and pond bathymetry. These attenuation factors were higher than that used in the land-use model. The reason was that the pond data were temporally limited and a more conservative value of 50% was more protective and defensible.

Similarly, the water column N validation dataset was also conservative. The model is validated to measured water column N. However, the model predicts average summer N concentrations. The very high or low measurements are marked as outliers. The effect is to make the N threshold more accurate and scientifically defensible. If a single measurement two times higher than the next highest data point in the series raises the average 0.05 mg N/L, this would allow for a higher “acceptable” load to the embayment. Marking the very high outlier is a way of preventing a single and rare bloom event from changing the N threshold for a system. This effectively strengthens the data set so that a higher margin of safety is not required.

Finally, the predicted reductions in benthic regeneration of N are most likely underestimates, i.e. conservative. The reduction is based solely on a reduced deposition of PON, due to lower primary production rates under the reduced N loading in these systems. As the N loading decreases and organic inputs are reduced, it is likely that rates of coupled remineralization-nitrification, denitrification and sediment oxidation will increase.

Benthic regeneration of N is dependent upon the amount of PON deposited to the sediments and the percentage that is regenerated to the water column versus being denitrified or buried. The regeneration rate projected under reduced N loading conditions was based upon two assumptions: (1) PON in the embayment in excess of that of inflowing tidal water (boundary condition) results from production supported by watershed N inputs and(2) presently enhanced production will decrease in proportion to the reduction in the sum of watershed N inputs and direct atmospheric N input. The latter condition would result in equal embayment versus boundary condition production and PON levels if watershed N loading and direct atmospheric deposition could be reduced to zero (an impossibility of course). This proportional reduction assumes that the proportion of remineralized N will be the same as under present conditions, which is almost certainly an underestimate. As a result, future N regeneration rates are overestimated which adds to the margin of safety.

Finally, the linked model accounted for all stormwater loadings and groundwater loadings in one aggregate allocation as a non point source and this aggregate load is accounted for in the load allocation. The method of calculating the WLA in the TMDL for regulated stormwater was conservative as it did not disaggregate this load from the modeled stormwater LA, which contributes to the margin of safety.

Finally, decreases in air deposition through continuing air pollution control efforts are unaccounted for this TMDL and provide another component of the margin of safety.

2. <u>Conservative sentinel station/target threshold nitrogen concentration</u>

Conservatism was used in the selection of the sentinel station and target threshold N concentration. The site was chosen that had stable eelgrass or benthic animal (infaunal) communities, and not those just starting to show impairment, which would have slightly higher N concentration. Meeting the target threshold N concentration at the sentinel station will result in reductions of N concentrations in the rest of the system.

3. <u>Conservative approach</u>

The target loads were based on tidally averaged N concentrations on the outgoing tide, which is the worst case condition because that is when the N concentrations are the highest. The N concentrations will be lower on the flood tides and therefore this approach is conservative.
In addition to the margin of safety within the context of setting the N threshold levels as described above, a programmatic margin of safety also derives from continued monitoring of this embayment to support adaptive management. This continuous monitoring effort provides the ongoing data to evaluate the improvements that occur over the multi-year implementation of the N management plan. This will allow refinements to the plan to ensure that the desired level of restoration is achieved.

Seasonal Variation

Since the TMDLs for the waterbody segments are based on the most critical time period, i.e. the summer growing season, the TMDLs are protective for all seasons. The daily loads can be converted to annual loads by multiplying by 365 (the number of days in a year). Nutrient loads to the embayment are based on annual loads for two reasons. The first is that primary production in coastal waters can peak in both the late winter-early spring and in the late summer-early fall periods. Second, as a practical matter, the types of controls necessary to control the N load, the nutrient of primary concern, by their very nature do not lend themselves to intra-annual manipulation since the majority of the N is from non-point sources. Thus, the annual loads make sense since it is difficult to control non-point sources of N on a seasonal basis and N sources can take considerable time to migrate to impacted waters.

TMDL Values for the Slocums and Little Rivers Embayment System

As outlined above, the total maximum daily loadings of N that would provide for the restoration and protection of the embayment were calculated by considering all sources of N grouped by natural background, point sources and non-point sources. A more meaningful way of presenting the loadings data from an implementation perspective is presented in Table 8. This table is based on data from Table ES-2 in the MEP Technical Report.

In this table the N loadings from the atmosphere and sediments are listed separately from the target watershed threshold loads which are composed of natural background N along with locally controllable N from the on-site subsurface wastewater disposal systems, storm water runoff and fertilizer sources. Because directly connected impervious areas were determined to be a significant source of N to this system in the Paskamansett and Destruction Brook subwatershed, a WLA was calculated for stormwater and presented as part of the TMDL in Table 8. A description of how the stormwater WLA and LA were determined has been described in the previous section.

Table 8: The Total Maximum Daily Load (TMDL) for Slocums and Little Rivers Embayment System, Represented as the Sum of the Calculated Target Threshold Loads, Atmospheric Deposition and Sediment Load

Sub-embayment	Target Threshold Watershed Load [1] (kg N/day)			Atmospheric Deposition (kg N/day)	Load from Sediments[5] (kg N/day)	TMDL[6] (kg N/day)
	Natural Background[2]	WLA[3]	LA[4]			
Slocum's River	3.44	0.005	2.32	6.16	0	11.92
Little River	5.63	0.002	2.51	1.36	8.90	18.4
Paskamansett River & Destruction Brook[7]	60.61	18.07	27.82	-	-	106.5
Barney's Joy River (North & South)	4.95	0.003	2.59	-	-	7.54
System Total	74.63	18.08	35.24	7.52	8.9	144.35

[1] Target threshold watershed load is the load from the watershed needed to meet the embayment target threshold Nitrogen concentration identified in Table 4. It is comprised of natural background, the WLA and LA.
[2] Natural background N load from Table ES-1 of the MEP Technical Report.
[3] WLA (from Table 7) is the impervious surfaces runoff from DCIA.
[4] LA is the remaining Target Watershed Load.
[5] Projected sediment N loadings obtained by reducing the present loading rates (Table 5) proportional to proposed watershed load reductions and factoring in the existing and projected future concentrations of PON. Negative sediment loads were set to zero.
[6] Sum of target threshold watershed load, sediment load and atmospheric deposition load.
[7] The two freshwater streams enter the headwaters of Slocums River. Though nutrient load is combined here, separate TMDLs are assigned in Appendix D.

In the case of the Slocums and Little Rivers embayment system the TMDL was calculated by projecting reductions in locally controllable on-site subsurface wastewater disposal systems. The nitrogen septic load reductions within the Slocums River Estuary West and East sub-watersheds were reduced by 76% along with an approximate 80% reduction in nitrogen septic load for Paskamansett River and Destruction Brook. However, septic nitrogen loading represents only a moderate portion of the total watershed N load. Stormwater runoff from impervious surfaces, farm animals and lawn and golf course fertilizers have also been identified as sources of nitrogen to this system.

In particular, stormwater runoff from impervious areas has been identified in the MEP Report as the most significant source of N in the Paskamansett/Destruction Brook subwatershed. As stated above, portions of Dartmouth, New Bedford and Freetown that contribute to this subwatershed are classified as Urban Areas (UAs) by the United States Census Bureau and are regulated under the NPDES Phase II permit programs. EPA's Phase II rule specifies that these communities must develop, implement, and enforce a storm water management program that is designed to reduce the discharge of pollutants to the maximum extent practicable, protect water quality, and satisfy the applicable water quality requirements of the Clean Water Act.

The NPDES permits which EPA has issued in Massachusetts to implement the Phase II Stormwater program do not establish numeric effluent limitations for stormwater discharges, rather, they establish narrative requirements, including best management practices, to meet the following six minimum control measures and to meet State Water Quality Standards.

1. public education and outreach particularly on the proper disposal of pet waste,
2. public participation/involvement,
3. illicit discharge detection and elimination,
4. construction site runoff control,
5. post construction runoff control, and
6. pollution prevention/good housekeeping.

As part of their applications for Phase II permit coverage, communities must identify the best management practices they will use to comply with each of these six minimum control measures and the measurable goals they have set for each measure. Therefore, compliance with the requirements of the Phase II stormwater permits in the communities of Dartmouth and New Bedford will contribute to the goal of reducing the nitrogen load as prescribed in this TMDL for the Paskamansett/Destruction Brook subwatershed.

Once again the goal of this TMDL is to achieve the identified target threshold N concentration at the identified sentinel station. The target load identified in this table represents one alternative-loading scenario to achieve that goal but other scenarios may be possible and acceptable as well. However, this scenario establishes the general degree and spatial pattern of reduction that will be required for restoration of this nitrogen impaired embayment.

Implementation Plans

EPA and MassDEP authorized most of the watershed communities of New Bedford and large portions of Dartmouth for coverage under the NPDES Phase II General Permit for Stormwater Discharges from Small Municipal Separate Storm Sewer Systems (MS4s) in 2003. EPA and MassDEP reissued the MS4 permit in April 2016. The reissued permit takes effect on March 31, 2017.

This TMDL forms the basis for implementation plans to meet the Nitrogen loading capacity established for the Slocums and Little Rivers Embayment System. As MS4 permittees, Dartmouth and New Bedford will be required to identify in their respective Storm Water Management Plans (SWMPs) and Annual Reports those discharges that are subject to TMDL related requirements, as identified in part 2.2.1. of the renewal permit, and those that are subject to additional requirements to protect water quality, as identified in part 2.2.2. of the renewal permit. Because this TMDL will be subject to EPA review and approval after issuance of the renewal permit, Dartmouth and New Bedford are subject to the additional requirements to protect water quality in part 2.2.2. for purposes of implementing this TMDL, and they are each required to comply with the applicable provisions in Appendix H to address their respective nitrogen discharges to the maximum extent practicable, as required by CWA Section 402(p)(3)(B)(iii). Although EPA's Phase II MS4 regulations only require a small MS4 to implement its program in the urbanized area subject to permitting, EPA and MassDEP nonetheless encourage permittees, including Dartmouth and New Bedford, to update and implement their respective SWMPs jurisdiction-wide to further water quality improvements.

The critical element of this TMDL process is achieving the sentinel station specific target threshold N concentrations presented in Table 4 that are necessary for the restoration and protection of water quality and eelgrass habitat within the Slocums and Little Rivers Embayment System. In order to achieve these target threshold N concentrations, N loading rates must be reduced throughout the Slocums embayment and preserved within the Little River embayment.

The water and habitat quality of the Little and Barney's Joy Rivers are presently considered to be "healthy" and no reductions of N loading are called for. Accordingly, the target N loading rates to these two systems are considered "pollution prevention" TMDLs. Pollution prevention TMDLs on these waterbodies will encourage the maintenance and protection of existing water quality and help prevent further degradation to waterbodies that are downstream or linked. These pollution prevention TMDLs will serve as a guide to help ensure that the Little River and Barney's Joy Rivers do not become impaired for N. (Note that previously the Little River was listed on the MA 2014 Integrated List of Waters as impaired. The new data indicate that this water body is not currently impaired due to nitrogen. As such MassDEP will petition the EPA to remove this segment from the current list.)

As previously noted, there is a variety of loading reduction scenarios that could achieve the target threshold N concentrations. Dartmouth and New Bedford can explore other loading reduction scenarios through additional modeling as part of their Comprehensive Wastewater Management Plan (CWMP). It must be demonstrated however, that any alternative implementation strategies will be protective of the entire embayment system and that none of the embayment will be negatively impacted. To this end, additional linked model runs can be performed by the MEP at a nominal cost to assist the planning efforts of the town in achieving target N loads that will result in the desired target threshold N concentration.

Because a significant portion of the of controllable N load is from septic systems for private residences the CWMP should assess the most cost-effective options for achieving the target N watershed loads, including but not limited to, sewering and treatment for N control of sewage and septage at either centralized or de-centralized locations and denitrifying systems for all private residences. The CWMP should include a schedule of the selected strategies and estimated timelines for achieving the N targets. However, the MassDEP realizes that an adaptive management approach may be used to observe implementation results over time and allow for adjustments based on those results. If a community chooses to implement TMDL measures without a CWMP it must demonstrate that these measures will achieve the target threshold N concentration. (Note: Communities that choose to proceed without a CWMP will not be eligible for State Revolving Fund loans.)

As discussed above, the MEP Technical Report has predicted that the threshold N concentration can be met by the prescribed reductions in septic loads only. However, because stormwater runoff contributes such a large percentage of the N load to the Slocums River, MassDEP recommends that Dartmouth and New Bedford continue to work towards reducing stormwater runoff N loads to the Paskamansett and Destruction Brook subwatersheds through the implementation of their Stormwater Management Programs (SWMPs) under their NPDES Phase II Stormwater permits.

The NPDES permit does not, however, establish numeric effluent limitations for storm water discharges. Maximum extent practicable is the statutory standard that establishes the level of pollutant reductions that regulated municipalities must achieve. The maximum extent practicable standard is a narrative effluent limitation that is satisfied through implementation of Stormwater Management Programs and achievement of measurable goals. Non-point source discharges are generally characterized as sheet flow runoff and are not categorically regulated under the NPDES program and can be difficult to manage. However, some of the same principles for mitigating point source impacts may be applicable. Portions of the watershed in Dartmouth and New Bedford are not currently regulated under the Phase II program. It is recommended that these municipalities consider expanding some or all of the six minimum control measures and other BMPs throughout their jurisdiction in order to minimize storm water contamination.

In addition to the Phase II Stormwater Permit program described above, the MassDEP issued a Stormwater Policy in1996 that established Stormwater Management Standards. In 2008 MassDEP revised the Stormwater Management Standards and the Massachusetts Stormwater Handbook to promote increased stormwater recharge, the treatment of more runoff from polluting land uses, low impact development (LID) techniques, pollution prevention, the removal of illicit discharges to stormwater management systems, and improved operation and maintenance of stormwater best management practices (BMPs). MassDEP applies the Stormwater Management Standards pursuant to its authority under the Wetlands Protection Act, M.G.L. c. 131, § 40, and the Massachusetts Clean Waters Act, M.G.L .c. 21, §§ 26-53. The revised Stormwater Management Standards have been incorporated in the Wetlands Protection Act Regulations, 310 CMR 10.05(6)(k) and the Water Quality Certification Regulations, 314 CMR 9.06(6)(a).The Massachusetts Stormwater Handbook can be found at: http://www.mass.gov/eea/agencies/massdep/water/regulations/massachusetts-stormwater-handbook.html

Also significant to implementation efforts are several groups that have been active in the protection of the Buzzards Bay watershed for many years. The Buzzards Bay National Estuary Program (NEP) joined the National Estuary Program in 1987. There are 28 NEPs around the country and they have become a model for watershed management and planning. The Buzzards Bay NEP acts as an advisory and planning unit of the Massachusetts Office of Coastal Zone Management. There are two not-for-profit active stewards of the Buzzards Bay, the Coalition for Buzzards Bay (CBB) and the Buzzards Bay Action Committee (BBAC). The CBB is a citizens group primarily focused on education and outreach and the BBAC, consisting of municipal officials, focusing on regulation and legislation issues. Today, both organizations are on the Buzzards Bay NEP's Steering Committee, where their mission is “To protect and restore water quality and living resources in Buzzards Bay and its surrounding watershed through the implementation of the Buzzards Bay Comprehensive Conservation and Management Plan” (CCMP) This document, originally published in 1991 was updated in October 2012 and the new draft is available for download at http://www.buzzardsbay.org/newccmp.htm). This plan is a blueprint for the protection and restoration of water quality and living resources in Buzzards Bay and its watershed. The Buzzards Bay NEP provides funding and technical assistance to municipalities and citizens to implement the recommended actions contained in the CCMP. The CCMP includes the following action plans:

- Managing Nitrogen-Sensitive Embayment's
- Protecting and Enhancing Shellfish Resources
- Controlling Stormwater Runoff
- Managing Sanitary Wastes from Boats
- Managing On-Site Systems
- Preventing Oil Pollution
- Protecting Wetlands and Coastal Habitat
- Planning for a Shifting Shoreline
- Managing Sewage Treatment Facilities
- Reducing Toxic Pollution
- Managing Dredging and Dredged Material Disposal

Through implementation of the action plan to control stormwater in the CCMP the Buzzards Bay NEP produced a mapping document, *"Atlas of Stormwater Discharges in the Buzzards Bay Watershed".* Data collected to produce the map sets remediation implementation priorities within the watershed. The storm water mapping effort is ongoing in areas not included in the original Atlas.(http://buzzardsbay.org/stormatlas.htm)

Dartmouth and New Bedford are urged to meet the target threshold N concentration by reducing N loadings from any and all sources, through whatever means are available and practical, including reductions in stormwater runoff and/or fertilizer use within the watershed through the establishment of local by-laws and/or the implementation of stormwater BMPs in addition to reductions in on-site subsurface wastewater disposal system loadings.

Based on land-use and the fact that most of the watershed is located within the Town of Dartmouth it appears that significant nitrogen management for the Slocums River restoration may be formulated and implemented through the Town of Dartmouth's actions. Although it is noted that much of the watershed area in New Bedford is presently serviced by the municipal wastewater system, cooperation with New Bedford on planning and management particularly with regard to management of stormwater from impervious surfaces, is still important to the long-term success of a restoration plan. The watershed of the Little River lies entirely within the Town of Dartmouth so management of this system is dependent on Dartmouth only.

The Town of Dartmouth has taken an active role in reducing the TN to the watershed since the start of the MEP project. Numerous sewer extensions within the Slocums and Little River Watersheds have been completed since the start of data collection in 2000. The Dartmouth Board of Health reports that 469 septic systems were abandoned and the residents tied in to the municipal system. An additional 399 substandard septic systems were upgraded to Title 5 where sewer was not available. Dartmouth passed comprehensive revisions to their Aquifer Protection Zoning By-law in 2005, which, in compliance with MassDEP Wellhead Protection requirements in the Drinking Water Regulations, requires onsite recharge of stormwater for residential and commercial properties with impervious areas greater than 15% or 2,500 square feet.

Dartmouth has required stormwater Best Management Practice (BMP) at three major commercial properties in the watershed since 2005 (North Dartmouth Mall, Faunce Corner Road, and Russell's Mills Road). Dartmouth, along with the Commonwealth of Massachusetts and local non-governmental organizations, has established permanent open space with the Slocums and Little Rivers watersheds. Dartmouth reports that approximately 8.6 square miles or 22% or the land area within the watershed is protected open space.

Massachusetts Department of Agricultural Resources, Plant Nutrient Application Requirements, 330 CMR 31.00, became effective December 2015. These regulations which require basic plant nutrient management plans for 10 or more acres and adherence to application and seasonal restrictions, will reduce the agricultural TN load entering the surface water and groundwater throughout Massachusetts, including Slocums and Little Rivers Estuarine System.

Climate Change:

MassDEP recognizes that long-term (25+ years) climate change impacts to southeastern Massachusetts, including the area of this TMDL, are possible based on known science. Massachusetts Executive Office of Energy and Environmental Affairs 2011Climate Change Adaptation Report: http://www.mass.gov/eea/waste-mgnt-recycling/air-quality/green-house-gas-and-climate-change/climate-change-adaptation/climate-change-adaptation-report.html predicts that by 2100 the sea level could be from 1 to 6 feet higher than the current position and precipitation rates in the Northeast could increase by as much as 20 percent. However, the details of how climate change will affect sea level rise, precipitation, streamflow, sediment and nutrient loading in specific locations are generally unknown. The ongoing debate is not about whether climate change will occur, but the rate at and the extent to which it will occur and the adjustments needed to address its impacts. EPA's 2012 Climate Change Strategy http://water.epa.gov/scitech/climatechange/upload/epa_2012_climate_water_strategy_full_report_final.pdf
states: "Despite increasing understanding of climate change, there still remain questions about the scope and timing of climate change impacts, especially at the local scale where most water-related decisions are made." For estuarine TMDLs in southeastern Massachusetts, MassDEP recognizes that this is particularly true, where water quality management decisions and implementation actions are generally made and conducted at the municipal level on a sub-watershed scale.

EPA's Climate Change Strategy identifies the types of research needed to support the goals and strategic actions to respond to climate change. EPA acknowledges that data are missing or not available for making water resource management decisions under changing climate conditions. In addition, EPA recognizes the limitation of current modeling in predicting the pace and magnitude of localized climate change impacts and recommends further exploration of the use of tools, such as atmospheric, precipitation and climate change models, to help states evaluate pollutant load impacts under a range of projected climatic shifts.

In 2013, EPA released a study entitled, "Watershed modeling to assess the sensitivity of streamflow, nutrient, and sediment loads to potential climate change and urban development in 20 U.S. watersheds." (National Center for Environmental Assessment, Washington D.C.; EPA/600/R-12/058F). The closest watershed to southeastern Massachusetts that was examined in this study is a New England coastal basin located between Southern Maine and Central

Coastal Massachusetts. These watersheds do not encompass any of the watersheds in the Massachusetts Estuary Project (MEP) region, and it has vastly different watershed characteristics, including soils, geography, hydrology and land use – key components used in a modeling analysis. The initial "first order" conclusion of this study is that, in many locations, future conditions, including water quality, are likely to be different from past experience. However, most significantly, this study did not demonstrate that changes to TMDLs (the water quality restoration targets) would be necessary for the region. EPA's 2012 Climate Change Strategy also acknowledges that the Northeast, including New England, needs to develop standardized regional assumptions regarding future climate change impacts. EPA's 2013 modeling study does not provide the scientific methods and robust datasets needed to predict specific long-term climate change impacts in the MEP region to inform TMDL development.

MassDEP believes that impacts of climate change should be addressed through TMDL implementation with an adaptive management approach in mind. Adjustments can be made as environmental conditions, pollutant sources, or other factors change over time. Massachusetts Coastal Zone Management (CZM) has developed a Storm Smart Coasts Program (2008) to help coastal communities address impacts and effects of erosion, storm surge and flooding which are increasing due to climate change. The program, www.mass.gov/czm/stormsmart offers technical information, planning strategies, legal and regulatory tools to communities to adapt to climate change impacts.

As more information and tools become available, there may be opportunities to make adjustments in TMDLs in the future to address predictable climate change impacts. When the science can support assumptions about the effects of climate change on the nitrogen loadings to Slocums and Little Rivers Embayment the TMDL can be reopened, if warranted.

The watershed communities of Dartmouth, New Bedford Westport, Acushnet and Freetown are urged to meet the target threshold N concentrations by reducing N loadings from any and all sources, through whatever means are available and practical, including reductions in on-site subsurface wastewater disposal system loadings as well as reductions in stormwater runoff and/or fertilizer use within the watershed through the establishment of local by-laws and/or the implementation of stormwater Best Management Practices (BMPs).

MassDEP's MEP Implementation Guidance report:
http://www.mass.gov/dep/water/resources/coastalr.htm#guidance provides N loading reduction strategies that are available to Dartmouth and New Bedford and that could be incorporated into the implementation plans. The following topics related to N reduction are discussed in the Guidance:

- Wastewater Treatment
  - On-Site Treatment and Disposal Systems
  - Cluster Systems with Enhanced Treatment
  - Community Treatment Plants
  - Municipal Treatment Plants and Sewers
- Tidal Flushing
  - Channel Dredging

        - Inlet Alteration
        - Culvert Design and Improvements
- Stormwater Control and Treatment *
        - Source Control and Pollution Prevention
        - Stormwater Treatment
- Attenuation via Wetlands and Ponds
- Water Conservation and Water Reuse
- Management Districts
- Land Use Planning and Controls
        - Smart Growth
        - Open Space Acquisition
        - Zoning and Related Tools
- Nutrient Trading

* Dartmouth and New Bedford are two of the 237 communities in Massachusetts covered by the Phase II storm water program requirements.

Monitoring Plan

MassDEP is of the opinion that there are two forms of monitoring that are useful to determine progress towards achieving compliance with the TMDL. MassDEP's position is that implementation will be conducted through an iterative process where adjustments maybe needed in the future. The two forms of monitoring include 1) tracking implementation progress as approved in the Dartmouth and New Bedford CWMP plans and 2) monitoring water quality and habitat conditions in the estuaries, including but not limited to, the sentinel stations identified in the MEP Technical Report.

The CWMP will evaluate various options to achieve the goals set out in the TMDL and the MEP Technical Report. It will also make a final recommendation based on existing or additional modeling runs, set out required activities, and identify a schedule to achieve the most cost effective solution that will result in compliance with the TMDL. Once approved by the Department tracking progress on the agreed upon plan will, in effect, also be tracking progress towards water quality improvements in conformance with the TMDL.

Relative to water quality, MassDEP believes that an ambient monitoring program much reduced from the data collection activities needed to properly assess conditions and to populate the model, will be important to determine actual compliance with water quality standards. Although the TMDL load values are not fixed, the target threshold N concentrations at the sentinel stations are fixed. Through discussions amongst the MEP it is generally agreed that existing monitoring programs which were designed to thoroughly assess conditions and populate water quality models can be substantially reduced for compliance monitoring purposes. Although more specific details need to be developed on a case-by-case basis MassDEP believes that about half the current effort (using the same data collection procedures) would be sufficient to monitor compliance over time and to observe trends in water quality changes. In addition, the benthic habitat and communities would require periodic monitoring on a frequency of about every 3-5 years. Finally, in addition to the above, existing monitoring conducted by MassDEP for eelgrass should continue into the future to observe any changes that may occur to eelgrass populations as a result of restoration efforts.

The MEP will continue working with the watershed communities to develop and refine monitoring plans that remain consistent with the goals of the TMDL. Through the adaptive management approach ongoing monitoring will be conducted and will indicate if water quality standards are being met. If this does not occur other management activities would have to be identified and considered to reach to goals outlined in this TMDL. It must be recognized however that development and implementation of a monitoring plan will take some time, but it is more important at this point to focus efforts on reducing existing watershed loads to achieve water quality goals.

Reasonable Assurances

When a TMDL is developed for waters impaired by both point and nonpoint sources, and a wasteload allocation (WLA) is based on an assumption that the nonpoint source load reductions will occur, EPA guidance requires states provide reasonable assurance that nonpoint control measures will achieve the expected load reductions necessary to meet the Water Quality Standards. EPA guidance also directs states to achieve TMDL allocations in waters only impaired by nonpoint sources, however reasonable assurances are not required. In the case of the Slocums/Little River system it has been estimated that about 18.1kg N/day out of a total watershed load of 144.35 kg N/day or roughly only 12.5 percent would be considered point source stormwater by EPA definition. As a result MassDEP believes reasonable assurance is not necessary. The MEP Linked Watershed-Embayment Model for the Slocums and Little Rivers Estuary Systems has demonstrated that if the recommended nonpoint source loads are removed from the system then the target nitrogen loading concentration in the embayment can be met.

MassDEP possesses the statutory and regulatory authority, under the water quality standards and/or the State Clean Water Act (CWA), to implement and enforce the provisions of the TMDL through its many permitting programs including requirements for N loading reductions from on-site subsurface wastewater disposal systems. However, because most non-point source controls are voluntary, reasonable assurance is based on the commitment of the locality involved. Dartmouth and New Bedford have demonstrated this commitment through the comprehensive wastewater planning that they initiated well before the generation of the TMDL. The communities expect to use the information in this TMDL to generate support from their citizens to take the necessary steps to remedy existing problems related to N loading from on-site subsurface wastewater disposal systems, stormwater, and runoff (including fertilizers), and to prevent any future degradation of these valuable resources.

Moreover, reasonable assurances that the TMDL will be implemented include enforcement of regulations, availability of financial incentives and local, state and federal programs for pollution control. EPA’s Storm water NPDES permit coverage will address discharges from municipally owned storm water drainage systems. Enforcement of regulations controlling non-point discharges include local implementation of the Commonwealth’s Wetlands Protection Act and Rivers Protection Act, Title 5 regulations for on-site subsurface wastewater disposal systems and other local regulations (such as the Town of Rehoboth’s stable regulations).

Financial incentives include federal funds available under Sections 319, 604 and 104(b) programs of the CWA, which are provided as part of the Performance Partnership Agreement between MassDEP and EPA. Other potential funds and assistance are available through the Massachusetts Department of Agriculture's Enhancement Program and the United States Department of Agriculture's Natural Resources Conservation Services. Additional financial incentives include income tax credits for Title 5 upgrades and low interest loans for Title 5 on-site subsurface wastewater disposal system upgrades available through municipalities participating in this portion of the state revolving fund program.

Statewide implementation of the stormwater management is being accomplished through a wide variety of federal, state, local, and non-profit programs and partnerships. It includes partnering with the Massachusetts Coastal Zone Management on the implementation of Section 6217 program. That program outlines both short and long term strategies to address urban areas and stormwater, marinas and recreational boating, agriculture, forestry, hydro modification, and wetland restoration and assessment. The CZM 6217 program also addresses TMDLs and nitrogen sensitive embayments and is crafted to reduce water quality impairments and restore segments not meeting state standards.

As the municipalities implement this TMDL the loading values (kg/day of N) will be used by MassDEP for guidance for permitting activities and should be used by local communities as a management tool.

Public Participation

To be completed after public comment period

References

Dartmouth (2014). Town of Dartmouth, NPDES Phase II Small MS4 General Permit Annual Report, Annual Report Number 11, Reporting Period: March 13 to March 14. Town of Dartmouth, Massachusetts.

ENSR International (2009). CN: 251.1. *Final Pathogen TMDL for the Buzzards Bay Watershed, March 2009*. ENSR International, 2 Technology Park Drive, Westford, MA Available online at: http://www.mass.gov/eea/docs/dep/water/resources/a-thru-m/buzzbay1.pdf

Environmental Protection Agency (2001). Nutrient Criteria Technical Guidance Manual: Estuarine and Coastal Waters (EPA-822-B-01-003). The United States Environmental Protection Agency, Washington D.C.. Available at: http://www2.epa.gov/nutrient-policy-data/nutrient-criteria-technical-guidance-manual-estuarine-and-coastal-waters

Environmental Protection Agency. (2010). *EPA's Methodology to Calculate Baseline Estimates of Impervious Area (IA) and Directly Connected Impervious Area (DCIA) for Massachusetts Communities*. Boston, MA. http://www.epa.gov/region1/npdes/stormwater/ma/IA-DCIA-Calculation-Methodology.pdf

Fall River (2014). City of Fall River, NPDES Phase II Small MS4 General Permit Annual Report, Annual Report Number 11, Reporting Period: April 1, 2013 – March 31, 2014. City of Fall River, Massachusetts.

Howes, B. E. Eichner, R. Acker, R. Samimy, J. Ramsey and D. Schlesinger (2012). *Massachusetts Estuaries Project Linked Watershed-Embayment Approach to Determine Critical Nitrogen Thresholds for the Slocums and Little Rivers Estuaries, Town of Dartmouth, MA.* Massachusetts Department of Environmental Protection, Boston, MA. Available online at: http://www.mass.gov/eea/agencies/massdep/water/watersheds/the-massachusetts-estuaries-project-and-reports.html

MassDEP (2003). CN 085.0. *Buzzards Bay Watershed 2000 Water Quality Assessment Report.* Massachusetts Department of Environmental Protection, Division of Watershed Management. Worcester, MA.

MassDEP (2016). CN 400.1. *Massachusetts Year 2014 Integrated List of Waters: Final Listing of the Condition of Massachusetts' Waters Pursuant to Sections 305(b), 314 and 303(d) of the Clean Water Act*. Massachusetts Department of Environmental Protection, Division of Watershed Management. Worcester, MA.

MassDEP (2007). *Massachusetts Surface Water Quality Standards (314 CMR 4.00).* Massachusetts Department of Environmental Protection, 1 Winter Street, Boston, MA.

Westport (2013). Town of Freetown, NPDES Phase II Small MS4 General Permit Annual Report, Annual Report Number 9, Reporting Period: April 1, 2012 – March 31, 2013. Town of Westport, Massachusetts

Appendix A: Overview of Applicable Water Quality Standards

Water quality standards of particular interest to the issues of cultural eutrophication are dissolved oxygen, nutrients, bottom pollutants or alterations, aesthetics, excess plant biomass, and nuisance vegetation. The Massachusetts water quality standards (314 CMR 4.0) contain numeric criteria for dissolved oxygen, but have only narrative standards that relate to the other variables. This brief summary does not supersede or replace 314 CMR 4.0 Massachusetts Water Quality Standards, the official and legal standards. A complete version of 314 CMR 4.0 Massachusetts Water Quality Standards is available online at
http://www.mass.gov/eea/agencies/massdep/water/regulations/314-cmr-4-00-mass-surface-water-quality-standards.html

Applicable Narrative Standards

314 CMR 4.05(5)(a) states "Aesthetics – All surface waters shall be free from pollutants in concentrations that settle to form objectionable deposits; float as debris, scum, or other matter to form nuisances, produce objectionable odor, color, taste, or turbidity, or produce undesirable or nuisance species of aquatic life."

314 CMR 4.05(5)(b) states "Bottom Pollutants or Alterations. All surface waters shall be free from pollutants in concentrations or combinations or from alterations that adversely affect the physical or chemical nature of the bottom, interfere with the propagation of fish or shellfish, or adversely affect populations of non-mobile or sessile benthic organisms."

314 CMR 4.05(5)(c) states, "Nutrients –Unless naturally occurring, all surface waters shall be free from nutrients in concentrations that would cause or contribute to impairment of existing or designated uses and shall not exceed the site specific criteria developed in a TMDL or as otherwise established by the Department pursuant to 314 CMR 4.00. Any existing point source discharge containing nutrients in concentrations that would cause or contribute to cultural eutrophication, including the excessive growth of aquatic plants or algae, in any surface water shall be provided with the most appropriate treatment as determined by the Department, including, where necessary, highest and best practical treatment (HBPT) for POTWs and BAT for non POTWs, to remove such nutrients to ensure protection of existing and designated uses. Human activities that result in the nonpoint source discharge of nutrients to any surface water may be required to be provided with cost effective and reasonable best management practices for nonpoint source control."

Description of Coastal and Marine Classes and Numeric Dissolved Oxygen Standards

Excerpt from 314 CMR 4.05(4) (a):

(a) Class SA. These waters are designated as an excellent habitat for fish, other aquatic life and wildlife, including for their reproduction, migration, growth and other critical functions, and for primary and secondary contact recreation. In certain waters, excellent habitat for fish, other aquatic life and wildlife may include, but is not limited to, seagrass. Where designated in the tables to 314 CMR 4.00 for shellfishing, these waters shall be suitable for shellfish

harvesting without depuration (Approved and Conditionally Approved Shellfish Areas). These waters shall have excellent aesthetic value.
1. Dissolved Oxygen. Shall not be less than 6.0 mg/l. Where natural background conditions are lower, DO shall not be less than natural background. Natural seasonal and daily variations that are necessary to protect existing and designated uses shall be maintained.

Excerpt from 314 CMR 4.05(3) (b):

(b) Class B. These waters are designated as a habitat for fish, other aquatic life and wildlife, including for their reproduction, migration, growth and other critical functions, and for primary and secondary contact recreation. Where designated in 314 CMR 4.06, they shall be suitable as a source of public water supply with appropriate treatment ("Treated Water Supply"). Class B waters shall be suitable for irrigation and other agricultural uses and for compatible industrial cooling and process uses. These waters shall have consistently good aesthetic value.

1. Dissolved Oxygen. Shall not be less than 6.0 mg/l in cold water fisheries and not less than 5.0 mg/l in warm water fisheries. Where natural background conditions are lower, DO shall not be less than natural background conditions. Natural seasonal and daily variations that are necessary to protect existing and designated uses shall be maintained

Waterbodies Not Specifically Designated in 314 CMR 4.06 or the tables to 314 CMR 4.00
Note many waterbodies do not have a specific water quality designation in 314 CMR 4.06 or the tables to 314 CMR 4.00**.** Coastal and Marine Classes of water are designated as Class SA and presumed High Quality Waters as described in 314 CMR 4.06 (4).

314 CMR 4.06(4):

(4) Other Waters. Unless otherwise designated in 314 CMR 4.06 or unless otherwise listed in the tables to 314 CMR 4.00, other waters are Class B, and presumed High Quality Waters for inland waters and Class SA, and presumed High Quality Waters for coastal and marine waters. Inland fisheries designations and coastal and marine shellfishing designations for unlisted waters shall be made on a case-by-case basis as necessary.

Applicable Antidegradation Provisions
Applicable antidegradation provisions are detailed in 314 CMR 4.04 from which an excerpt is provided:

Excerpt from 314 CMR 4.04:
4.04:Antidegradation Provisions

(1) Protection of Existing Uses. In all cases existing uses and the level of water quality necessary to protect the existing uses shall be maintained and protected.

(2) Protection of High Quality Waters. High Quality waters are waters whose quality exceeds minimum levels necessary to support the national goal uses, low flow waters, and

other waters whose character cannot be adequately described or protected by traditional criteria. These waters shall be protected and maintained for their existing level of quality unless limited degradation by a new or increased discharge is authorized by the Department pursuant to 314 CMR 4.04(5). Limited degradation also may be allowed by the Department where it determines that a new or increased discharge is insignificant because it does not have the potential to impair any existing or designated water use and does not have the potential to cause any significant lowering of water quality.

(3) Protection of Outstanding Resource Waters. Certain waters are designated for protection under this provision in 314 CMR 4.06. These waters include Class A Public Water Supplies (314 CMR 4.06(1)(d)1.) and their tributaries, certain wetlands as specified in 314 CMR 4.06(2) and other waters as determined by the Department based on their outstanding socio-economic, recreational, ecological and/or aesthetic values. The quality of these waters shall be protected and maintained.

(a) Any person having an existing discharge to these waters shall cease said discharge and connect to a Publicly Owned Treatment Works (POTW) unless it is shown by said person that such a connection is not reasonably available or feasible. Existing discharges not connected to a POTW shall be provided with the highest and best practical method of waste treatment determined by the Department as necessary to protect and maintain the outstanding resource water.

(b) A new or increased discharge to an Outstanding Resource Water is prohibited unless:

1. the discharge is determined by the Department to be for the express purpose and intent of maintaining or enhancing the resource for its designated use and an authorization is granted as provided in 314 CMR 4.04(5). The Department's determination to allow a new or increased discharge shall be made in agreement with the federal, state, local or private entity recognized by the Department as having direct control of the water resource or governing water use; or

2. the discharge is dredged or fill material for qualifying activities in limited circumstances, after an alternatives analysis which considers the Outstanding Resource Water designation and further minimization of any adverse impacts. Specifically, a discharge of dredged or fill material is allowed only to the limited extent specified in 314 CMR 9.00 and 314 CMR 4.06(1)(d). The Department retains the authority to deny discharges which meet the criteria of 314 CMR 9.00 but will result in substantial adverse impacts to the physical, chemical, or biological integrity of surface waters of the Commonwealth

(4) Protection of Special Resource Waters. Certain waters of exceptional significance, such as waters in national or state parks and wildlife refuges, may be designated by the Department in 314 CMR 4.06 as Special Resource Waters (SRWs). The quality of these waters shall be maintained and protected so that no new or increased discharge and no new or increased discharge to a tributary to a SRW that would result in lower water quality in the SRW may be allowed, except where:

(a) the discharge results in temporary and short term changes in the quality of the SRW, provided that the discharge does not permanently lower water quality or result in water quality lower than necessary to protect uses; and

(b) an authorization is granted pursuant to 314 CMR 4.04(5).

(5) Authorizations.

(a) An authorization to discharge to waters designated for protection under 314 CMR 4.04(2) may be issued by the Department where the applicant demonstrates that:

1. The discharge is necessary to accommodate important economic or social development in the area in which the waters are located;

2. No less environmentally damaging alternative site for the activity, receptor for the disposal, or method of elimination of the discharge is reasonably available or feasible;

3. To the maximum extent feasible, the discharge and activity are designed and conducted to minimize adverse impacts on water quality, including implementation of source reduction practices; and

4. The discharge will not impair existing water uses and will not result in a level of water quality less than that specified for the Class.

(b) An authorization to discharge to the narrow extent allowed in 314 CMR 4.04(3) or 314 CMR 4.04(4) may be granted by the Department where the applicant demonstrates compliance with 314 CMR 4.04(5)(a)2. through 314 CMR 4.04(5)(a)4.

(c) Where an authorization is at issue, the Department shall circulate a public notice in accordance with 314 CMR 2.06. Said notice shall state an authorization is under consideration by the Department, and indicate the Department's tentative determination. The applicant shall have the burden of justifying the authorization. Any authorization granted pursuant to 314 CMR 4.04 shall not extend beyond the expiration date of the permit.

(d) A discharge exempted from the permit requirement by 314 CMR 3.05(4) (discharge necessary to abate an imminent hazard) may be exempted from 314 CMR 4.04(5) by decision of the Department.

(e) A new or increased discharge specifically required as part of an enforcement order issued by the Department in order to improve existing water quality or prevent existing water quality from deteriorating may be exempted from 314 CMR 4.04(5) by decision of the Department.

(6) The Department applies its Antidegradation Implementation Procedures to point source discharges subject to 314 CMR 4.00.

(7) Discharge Criteria. In addition to the other provisions of 314 CMR 4.00, any authorized Discharge shall be provided with a level of treatment equal to or exceeding the requirements of the Massachusetts Surface Water Discharge Permit Program (314 CMR 3.00). Before authorizing a discharge, all appropriate public participation and intergovernmental coordination shall be conducted in accordance with Permit Procedures (314 CMR 2.00).

Thus, the assessment of eutrophication is based on site-specific information within a general framework that emphasizes impairment of uses and preservation of a balanced indigenous flora and fauna. This approach is recommended by the US Environmental Protection Agency in their draft Nutrient Criteria Technical Guidance Manual for Estuarine and Coastal Marine Waters (EPA-822-B-01-003, Oct 2001). The Guidance Manual notes that lakes, reservoirs, streams and rivers may be subdivided by classes, allowing reference conditions for each class and facilitating cost-effective criteria development for nutrient management. However, individual estuarine and coastal marine waters tend to have unique characteristics and development of individual water body criteria is typically required.

Appendix B: Summary of the Nitrogen Concentrations for Slocums and Little Rivers Embayment System

Table B-1: Summary of Nitrogen Concentrations for Slocums and Little Rivers Embayment System, 2000-2006.

Measured data, and modeled Total Nitrogen concentrations for the Slocums River and Little River System. All concentrations are given in mg/L N. "Data mean" values are calculated as the average of the separate yearly means. Data are provided courtesy of the Coalition for Buzzards Bay (BayWatchers; 2000-06) and the Coastal Systems Program at SMAST (2004-05).

Sub-Embayment	Head Slocums	Upper Slocums	Upper Slocums	Mid Slocums	Mid Slocums	Mid Slocums	Lower Slocums / Giles	Lower Slocums	Lower Slocums	Inner Little River	Basin Little River	Inlet - Little River
Monitoring station	SRT-3	SRT-4	SRT-5	SRT-6	SRT-7	SRT-10	SRT-11	SRT-12	SRT-13	SRT-14	SRT-15	SRT-16
2000 mean	0.790			0.603				0.407				0.499
2001 mean	1.432			0.854				0.560				0.499
2002 mean	1.274			0.674				0.451				0.505
2003 mean	1.520			0.824								0.500
2004 mean	1.090	0.667	0.669	0.544	0.438	0.388	0.369	0.403	0.312	0.482	0.479	0.366
2005 mean	1.041	0.612	0.602	0.546	0.435	0.411	0.406	0.324	0.262	0.369	0.343	0.331
2006 mean	1.458			0.890								0.470
mean	1.175	0.641	0.636	0.620	0.437	0.399	0.385	0.390	0.285	0.409	0.403	0.394
s.d. all data	0.343	0.103	0.145	0.177	0.074	0.091	0.059	0.113	0.056	0.085	0.130	0.111
N	43	15	24	50	31	23	16	42	33	17	18	53
model min	1.442	0.845	0.656	0.532	0.419	0.301	0.348	0.293	0.287	0.327	0.313	0.289
model max	1.563	1.137	0.996	0.854	0.726	0.601	0.502	0.541	0.463	0.406	0.388	0.383
model average	1.499	0.994	0.826	0.690	0.586	0.450	0.398	0.392	0.337	0.365	0.349	0.325

Appendix C: Estimating the wasteload allocation (WLA) from runoff of all directly connected impervious areas (DCIA) within the Slocums and Little Rivers watershed.

Impervious surfaces such as roadways, parking lots, rooftops, sidewalks, driveways, and other pavements impede stormwater infiltration and generate surface runoff. It is widely known that the amount of impervious area (IA) in a watershed is correlated with a decrease in water and habitat quality including increased flood peaks and frequency, increased sediment, nutrient, and other pollutant levels, channel erosion, impairments to aquatic biota, and reduced recharge to groundwater. Directly connected impervious area (DCIA) is defined as the portion of IA with a direct hydraulic connection to the waterbody via continuous paved surfaces, gutters, drain pipes, or other conventional conveyance and detention structures that do not reduce runoff volume. (See http://www.epa.gov/region1/npdes/stormwater/ma/MADCIA.pdf)
DCIA does not include:

- IA draining to stormwater practices designed to meet recharge and other volume reduction criteria.
- Isolated IA with an indirect hydraulic connection to the MS4, or that otherwise drain to a pervious area.
- Swimming pools or man-made impoundments, unless drained to an MS4.
- The surface area of natural waterbodies (e.g., wetlands, ponds, lakes, streams, rivers).

When determining the TMDL for a pollutant, MassDEP has decided that stormwater from all areas defined as DCIA's should be considered part of the stormwater waste load allocation (WLA) regardless of whether the area is part of an EPA designated "urbanized area" and as such subject to the NPDES Phase II General Permit for stormwater discharges from Small Municipal Separate Storm Sewer Systems (MS4s). Since there are no other point sources of nitrogen to the Slocums and Little Rivers watershed, the WLA is simply the stormwater DCIA contribution.

To determine the extent of DCIA in the watershed the EPA NPDES Stormwater Regulated Communities website (http://www.epa.gov/region1/npdes/stormwater/ma.html) was consulted. This site contains community specific information on all of the MS4 Stormwater Permits, including maps showing the geographic extent of permit coverage (designated urbanized area) as well as the number of acres of impervious area (IA) and estimated directly connected impervious area (DCIA) by subwatershed for each regulated community. Statistics available from this site for the watershed area in each town as well as the total watershed area are listed in Table B-1.

To complete the WLA calculation, the total stormwater load from impervious surfaces as determined by the MEP study (28 kg N/day from Table IV-6 in the MEP Technical Report) was multiplied by 0.64 (the percentage of IA that was determined to be DCIA in the watershed - see Table B-1).The resulting value (18 kg N/day) is the WLA and the remaining 10 kg N/day is assigned to the nonpoint source contribution or the load allocation (LA).

Table C-1: Impervious area statistics for the Slocums and Little Rivers watershed by municipality.

Town Sub-watersheds	Total Area (acres)	IA (acres)	% IA of Total Area	DCIA (acres)	% DCIA of IA	Urbanized Area (acres)	DCIA in Urbanized Area (acres)	% DCIA in Urbanized Area
Dartmouth	18753.43	1329.66	8.5	898.87	67.6%	4760.38	613.52	12.9%
New Bedford	6371.48	1181.28	18.5	877.71	74.3%	4205.2	819.73	19.5%
Freetown	7.01	2.05	29.3	1.69	82.4%	0.99	0.32	32.3%
Slocums/Little Watershed	25131.9	2777.95	11.1	1778.27	64%	8966.57	1433.57	16%

From: http://www.epa.gov/region1/npdes/stormwater/ma.html

Appendix D: Summary of TMDLs for the Slocums and Little Rivers Embayment System

Table D-1: Slocums and Little Rivers Embayment System – 3 Total Nitrogen TMDLs, 2 Pollution Prevention* TMDLs.

Sub-embayment	**Segment ID**	**Impairment/TMDL Status**	**TMDL kg N/day**
Slocums River	MA95-34	Impaired for Estuarine Bioassessments, Nitrogen (Total), Fecal Coliform	**11.92**
Little River	MA95-66	Determined not to be impaired for Nitrogen (Total) during the development of this TMDL, but Pollution Prevention TMDL needed to protect the embayment.	18.4*
Paskamansett River	MA95-11**	Determined to be impaired for nutrients (Estuarine Bioassessments, Nitrogen (Total)) during the development of this TMDL.	**91.59**
Destruction Brook	MA95-90_2018**		**14.91**
Barneys Joy Rivers (North and South)	**--**	Not impaired for Nitrogen (Total), but Pollution Prevention TMDL needed since embayments are linked.	7.54*
System Total			144.35

*Pollution Prevention TMDLs (kg-N/day) for community planning and to prevent further downstream impairment.
**Water body segment to be listed as impaired in a future Integrated List of Waters.